PB88-191176

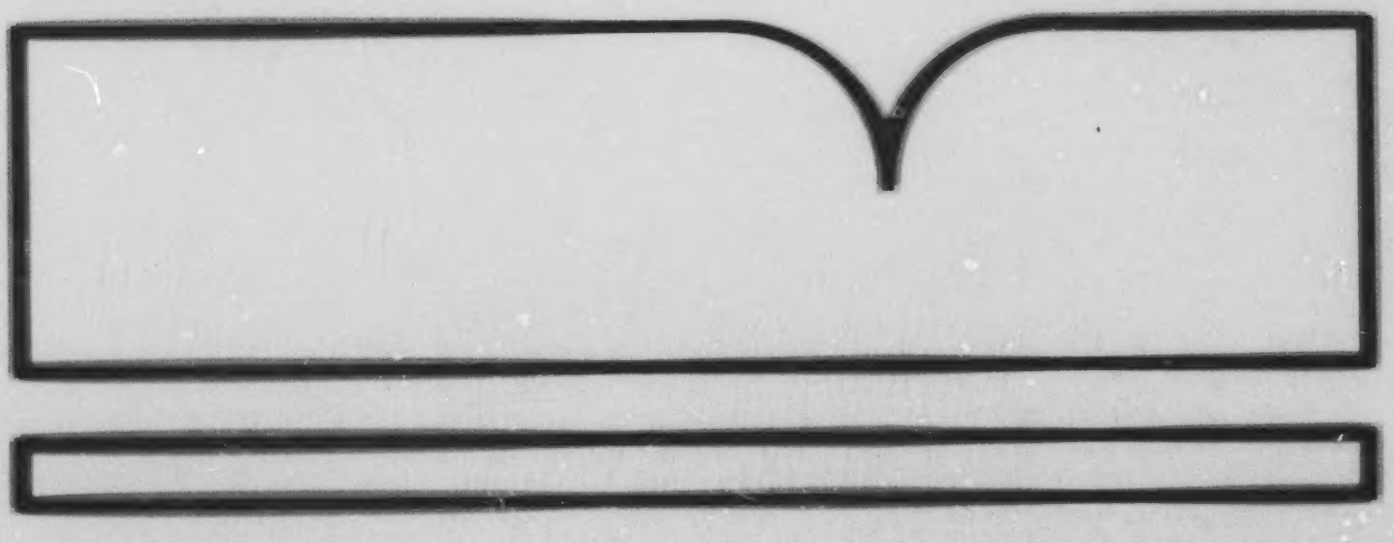
Industrial Combustion Emissions (ICE) Model, Version 6.0. Software Description

Energy and Environmental Analysis, Inc.
Arlington, VA

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

Feb 88



U.S. Department of Commerce
National Technical Information Service

PB88-191176

EPA/600/8-88/009
February 1988

INDUSTRIAL COMBUSTION EMISSIONS MODEL (VERSION 6.0) SOFTWARE DESCRIPTION

by

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EPA Contracts No. 68-02-4202 and 68-02-4384

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This study was conducted in cooperation with the
National Acid Precipitation Assessment Program

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REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA/600/8-88/009 EPA/SW/MT-88/02b	3. RECIPIENT'S ACCESSION NO. PB88-191176
4. TITLE AND SUBTITLE Industrial Combustion Emissions Model (Version 6.0) Software Description	5. REPORT DATE February 1988 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Tim Hogan	8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Energy and Environmental Analysis, Inc. 1655 North Fort Myer Drive Arlington, Virginia 22209	10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO. 68-02-4202 and -4384
12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development Air and Energy Engineering Research Laboratory Research Triangle Park, NC 27711	13. TYPE OF REPORT AND PERIOD COVERED Final; 3/85 - 2/86 14. SPONSORING AGENCY CODE EPA/600/13

15. SUPPLEMENTARY NOTES AEERL project officer is Larry G. Jones, Mail Drop 62, 919/541-7716. EPA-600/8-88-007b is related magnetic tape. For magnetic tape, see: PB88-172226

16. ABSTRACT The report describes the software of the Industrial Combustion Emissions (ICE) model, developed to support the EPA's analysis of acid deposition control alternatives. The model projects industrial fossil-fuel-fired boiler fuels, air emissions, and costs by state for 1985, 1990, 1995, 2000, 2010, 2020, and 2030. The current base year in the ICE model (Version 3) is 1980. Fuels include natural gas, distillate and residual fuel oil, and coal. Air emissions include sulfur oxides, sulfates, and nitrogen oxides. The report describes the structure of the ICE model (Version 6.0) computer programs, its input and output data files, major internal variables and constants, and the use of comment statements in the model's source code for one of the subroutines. It does not provide the necessary Job Control Language to run the model.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Emission	Pollution Control	13B	14G
Mathematical Models	Sulfur Oxides	Stationary Sources		07B
Fossil Fuels	Sulfates		12A	
Combustion	Nitrogen Oxides	Industrial Combustion Emissions (ICE) Model	21D	
Boilers			21B	
			13A	

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 100
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ABSTRACT

The Industrial Combustion Emissions (ICE) Model is one of four stationary source emission and control cost forecasting models developed by the Air and Energy Engineering Research Laboratory for the National Acid Precipitation Assessment Program. The ICE Model projects air pollution emissions (sulfur dioxide, sulfates, nitrogen oxides and particulate matter), costs and fuel mix for industrial fossil fuel-fired (natural gas, distillate and residual fuel oil and coal) boilers by State and year (1980 baseline, 1985, 1990, 1995, 2000, 2010, 2020, and 2030).

This document describes the ICE Model Version 6.0 computer program input and output data files, major internal variables and constants.

The ICE Model (Version 6.0) is available for remote terminal access and operation at the NCC. A transcription of the ICE Model is also available on magnetic tape. For information on operating the model at the NCC or obtaining a copy on magnetic tape, contact the National Technical Information Service (NTIS). Information can be obtained from Lois Grooms, NTIS, 5285 Port Royal Road, Springfield, VA 22161, 703/487-4808, or Larry Jones, USEPA, Air and Energy Engineering Research Laboratory, Mail Drop 62, Research Triangle Park, NC 27711, 919/541-7716.

EPA/600/8-88/007b is EPA's identification number for the Version 6.0 magnetic tape.

CONTENTS

	Page
Abstract	iii
Figures	iv
Tables	v
1. INTRODUCTION	1
2. COMPUTER PROGRAMS	2
CREATE6	2
FLCH6	7
TABLE6	13
3. DATA FILES	15
4. INTERNAL VARIABLES	33
5. CONSTANTS	70
APPENDIX A: INDEX OF MAJOR ARRAYS, SCALARS AND CONSTANTS	A-1
APPENDIX B: FIPS STATE CODES	B-1
APPENDIX C: FLOWCHARTS FOR SELECTED SUBROUTINES	C-1
APPENDIX D: CONVERSION FACTORS AND ABBREVIATIONS	D-1

FIGURES

Number		Page
2-1	ICE Model Jobs	3
2-2	CREATE6 PGM	4
2-3	FLCH6 PGM	10
2-4	Fuel Type Selection in FLCH6 PGM	11
2-5	GDPOL, RESID and COAL Subroutines in FLCH6 PGM	12
2-6	TABLE6 PGM	14
3-1	Federal Regions of the United States	29
C-1	Subroutines RESID and COAL	C-2
C-2	Subroutine FCOPT	C-3

TABLES

Number		Page
2-1	CREATE6 Data Files	5
2-2	FLCH6 Data Files	8
3-1	ICE Model Data Files	16
3-2	File Description: AQCRCDF	17
3-3	File Description: FCOPTN	18
3-4	File Description: FCOPTY	19
3-5	File Description: NEWSIPS2	20
3-6	File Description: SIZCUDIS	21
3-7	File Description: RYEARXX	22
3-8	File Description: RETRCOST	23
3-9	File Description: BLRPOP and BLRAFC4	24
3-10	File Description: BTUPOP	26
3-11	File Description: BTURTC	27
3-12	File Description: NUMCOL	28
3-13	Definitions of Selected Variables	30
3-14	State Codes	31
3-15	IPOLUT	32

SECTION 1

INTRODUCTION

The Industrial Combustion Emissions (ICE) Model was developed by Energy and Environmental Analysis, Inc. (EEA) for EPA's Air and Energy Engineering Research Laboratory to support EPA's analysis of acid deposition control alternatives. The ICE Model is one of a group of National Acid Precipitation Assessment Program sectoral emissions models. The ICE Model projects industrial fossil fuel-fired boiler:

- Fuel mix (natural gas, distillate and residual fuel oil, and coal)
- Air emissions (sulfur dioxide, sulfates, nitrogen oxides and particulate matter)
- Costs

by State for 1985, 1990, 1995, 2000, 2010, 2020, and 2030. The current base year in the ICE Model (Version 6.0) is 1980.

All ICE Model computer programs have been written in FORTRAN77. The ICE Model was developed on the IBM 3090 Model 200 computer system at EPA's National Computer Center in Research Triangle Park, North Carolina. All programs have been compiled using the FORTVCL utility on EPA's IBM system.

This report is organized to describe the structure of the ICE Model computer programs (Section 2), the ICE Model input and output data files (Section 3), and define major internal variables and constants used in the ICE Model (Sections 4 and 5).

The necessary Job Control Language and operating instructions to run the ICE Model are presented in a separate report.

SECTION 2

COMPUTER PROGRAMS

The ICE Model Version 6.0 consists of three major computer programs that are run in batches:

- CREATE6
- FLCH6
- TABLE6

CREATE6 and FLCH6 are each run for every output year. Since there are seven forecast years (1985, 1990, 1995, 2000, 2010, 2020, and 2030), CREATE6 and FLCH6 must be run seven times in the proper sequence (see Figure 2-1). After these 14 jobs (seven CREATE6 and seven FLCH6) have been executed, TABLE6 is run. However, it is possible to run a subset of the years (e.g., 1985, 1990, 1995, and 2000), but intermediate run years cannot be skipped (i.e., running 1990 without running 1985).

CREATE6

CREATE6 projects the distribution of the major industrial boiler characteristics. CREATE6 reduces fossil fuel consumption in existing industrial boilers by an amount determined from the retirement rate of units specified in the input files. Similarly, it increases fuel consumption in new industrial boilers by an amount determined from new capacity growth contained in the input files. For new units, it assigns the boiler size, expected annual capacity utilization rate, SIP, previous coal experience assumption (yes or no) and random variables which are used in FLCH6. Figure 2-2 shows the four subroutines in CREATE6. There are about 500 lines of source code in CREATE6.

Table 2-1 lists the input and output files for CREATE6 when the run year is 1985. The following discussion describes how each subroutine interacts with these files and gives a description of the contents of each file.

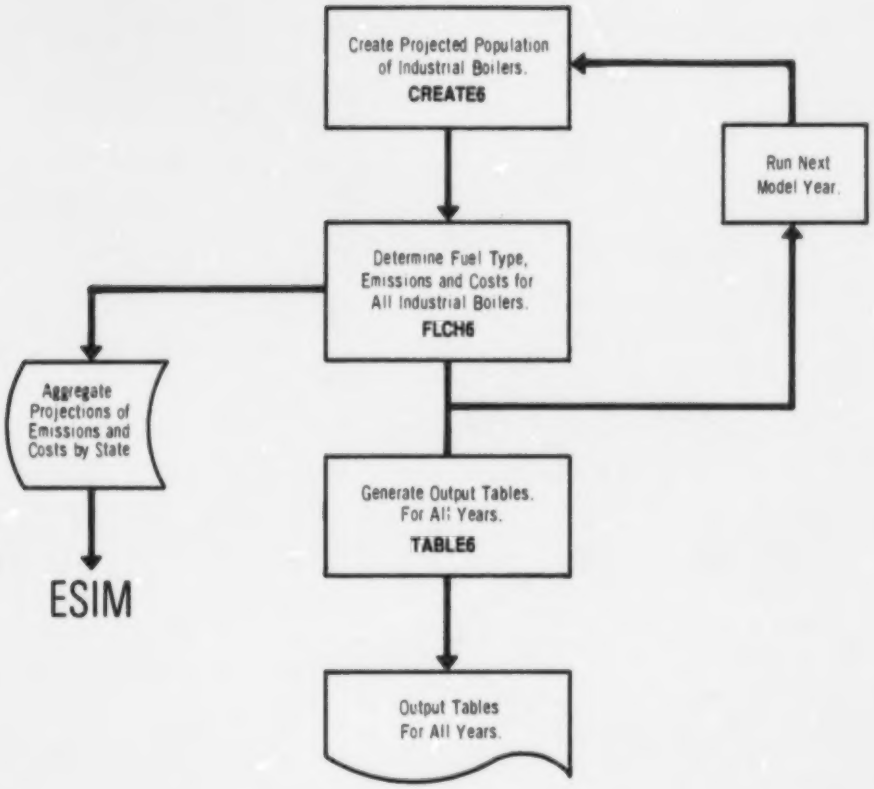

Create Projected Population of Industrial Boilers.
CREATE6
Run Next Model Year.
Determine Fuel Type, Emissions and Costs for All Industrial Boilers.
FLCH6
Aggregate Projections of Emissions and Costs by State
ESIM
Generate Output Tables. For All Years.
TABLE6
Output Tables For All Years.

Figure 2–1. ICE Model jobs.

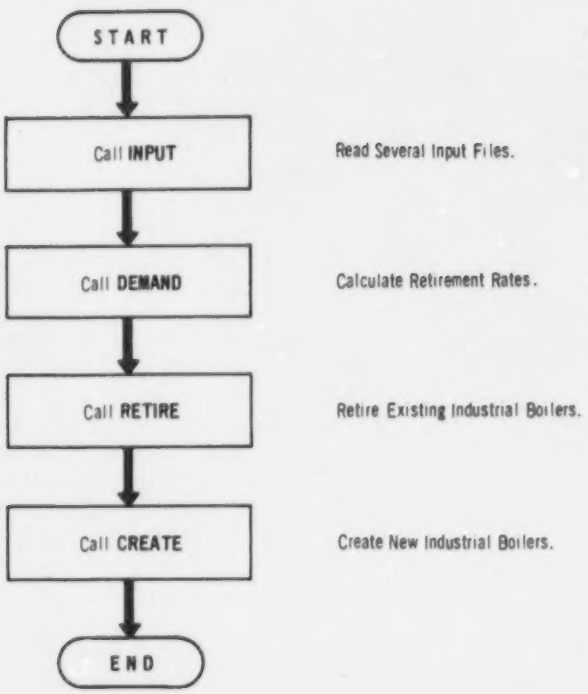


Figure 2–2. CREATE6 PGM.

TABLE 2-1. CREATE6 DATA FILES[a]

JCL unit number	Input/ output	Read by	Created by	File name
1	Input	Sub.INPUT	Standard	ICEMODEL.BASE80.BTUPOP.DATA
2	Input	Sub.INPUT	User	ICEMODEL.?.SIPMOD.DATA
3	Input	Sub.INPUT	User	ICEMODEL.?.DEMSCEN.DATA
4	Output	FLCH6[a]	Sub.RETIRE,CREATE	ICEMODEL.?85.BTUPOP.DATA
8	Input	Sub.RETIRE	Standard	ICEMODEL.BASE80.BLRAFC4.DATA
9	Output	FLCH6[a]	Sub.RETIRE,CREATE	ICEMODEL.?.BLRPOP.DATA
10	Input	Sub.INPUT	Standard	ICEMODEL.FIXED.SIZCUDIS.DATA
11	Input	Sub.INPUT	Standard	ICEMODEL.FIXED.AQCRCDF.DATA
12	Input	Sub.INPUT	Standard	ICEMODEL.FIXED.NEWSIPS2.DATA
13	Input	Sub.INPUT	Standard	ICEMODEL.FIXED.RYEAR85.DATA
16	Input	Sub.INPUT	Standard	ICEMODEL.BASE80.BTURTC.DATA
17	Input	Sub.INPUT	Standard	ICEMODEL.BASE80.NUMCOL.DATA
18[b]	Input	Sub.DEMAND	Sub.RETIRE,CREATE	ICEMODEL.?85.BTUPOP.DATA
19[c]	Input	Sub.DEMAND	Sub.RETIRE,CREATE	ICEMODEL.?90.BTUPOP.DATA
20[c]	Input	Sub.DEMAND	Sub.RETIRE,CREATE	ICEMODEL.?95.BTUPOP.DATA

[a]When "CY=85".

[b]Not used when CY=85. Only used when CY=20 or 30.

[c]Not used when CY=85. Only used when CY=30.

Ten input files are read in subroutine INPUT.*

- ICEMODEL.FIXED.RYEARXX.DATA contains only three data elements: the run year, the period (five or ten years) since the previous run year and the average market penetration rate of AFBC (see Table 3-7).
- ICEMODEL.?XX.BTUPOP.DATA consists of three matrices which contain industrial boiler fossil fuel consumption subtotals by State and industry group for the previous run year (see Table 3-10).
- ICEMODEL.?.SIPMOD.DATA is an ICE Model user-created file which contains SO_2 emissions standards for existing industrial boilers by boiler size class (eight) and fuel type (residual fuel oil and coal).
- ICEMODEL.?.DEMSCEN.DATA is an ICE Model user-created file which includes projected fuel prices and control totals for total projected fossil fuel demand in industrial boilers by year, State and industry group.
- ICEMODEL.?XX.BLRAFC4.DATA contains the industrial boiler fuel choice, air emission rates, and costs from the previous run year (see Table 3-9).
- ICEMODEL.FIXED.SIZCUDIS.DATA contains a distribution of new industrial boiler sizes and annual capacity utilization rates by industry group (see Table 3-6).
- ICEMODEL.FIXED.AQCRCDF.DATA includes a distribution of Air Quality Control Regions by State. This file is used to assign AQCR's to new industrial boilers (see Table 3-2).
- ICEMODEL.FIXED.NEWSIPS2.DATA contains SO_2, PM and NO_x emission limits for existing industrial boilers by AQCR, fuel type (residual fuel oil and coal) and boiler size group (see Table 3-5).
- ICEMODEL.?XX.BTURTC.DATA includes industrial boiler fossil fuel consumption subtotals for existing oil/gas units which retrofitted to coal in the previous run year (see Table 3-11).
- ICEMODEL.?XX.NUMCOL.DATA includes only two data elements, an estimate of the total number of industrial plants with coal-burning experience in two areas of the county (Federal regions 3, 4, and 5 versus the rest of the country) in the previous run year (see Table 3-12).

Note that for six of the above ten input files, the user must assign numbers or letters for ? or XX to designate a matrix of data. XX denotes the year and ? refers to a user-specified label.

If the run year is 2020 or 2030, subroutine DEMAND reads unit 18,

---

*The "?" in these file names is defined by the model operator in JCL (the value for "CYSC" -- see the User's Manual). "XX" is the run year (see Table 3-7).

ICEMODEL.?85.BTUPOP.DATA, an output file from the 1985 CREATE6 job. If the run year is 2030, subroutine DEMAND also reads unit 19, ICEMODEL.?90.BTUPOP.DATA, and unit 20, ICEMODEL.?95.BTUPOP.DATA, which are output files from the 1990 and 1995 CREATE6 jobs.

Subroutine RETIRE reads ICEMODEL.?XX.BLRAFC4.DATA, an output file from the FLCH6 job for the previous run year. This data file includes existing industrial boiler characteristics.

Subroutine RETIRE retires existing industrial boilers and modifies State Implementation Plan (SIP) air emission limits. This subroutine writes existing industrial boiler records (after retirement) to ICEMODEL.?.BLRPOP.DATA, an input file for the FLCH6 program. Subroutine RETIRE also writes two matrices (BASEOG and BASECL) to ICEMODEL.?XX.BTUPOP.DATA, an input file in the next CREATE6 job for the following run year.

Subroutine CREATE determines the size (MMBtu/hr), annual capacity utilization rate, SIP, previous coal experience assumptions (yes or no) of each new industrial fossil fuel-fired boiler. This subroutine writes a matrix (XNEWCM) to ICEMODEL.?XX.BTUPOP.DATA, an input file in the next CREATE6 job for the following run year. Subroutine CREATE also writes new industrial boiler records to ICEMODEL.?.BLRPOP.DATA, an input file for the FLCH6 program.

FLCH6

The FLCH6 program calculates the fuel type, air emissions rates and costs for each new and existing industrial boiler record processed by the CREATE6 program. There are about 4,700 lines of source code in FLCH6.

Table 2-2 presents the FLCH6 input and output files when the run year is 1985. The following discussion describes how each subroutine interacts with these files and gives a description of the contents of each file.

The FLCH6 control program reads:

- ICEMODEL.FIXED.FCOPTY.DATA (see Table 3-4) or ICEMODEL.FIXED.FCOPTN.DATA (see Table 3-3) represents the selection of the fuel choice decision logic for new industrial boilers.
- ICEMODEL.FIXED.RYEARXX.DATA (see Table 3-7) includes the run year and the number of years since the previous run year and the average

TABLE 2-2. FLCH6 DATA FILES[a]

JCL unit number	Input/ output	Read by	Created by	File name
1	Input	Sub.STREAM, FLSPEC	User	ICEMODEL.?.DEMSCEN.DATA
2	Output	FLCH6[b]	Sub.ENDOUT	ICEMODEL.?.ESIM.DATA
4	Input	Sub.ENDOUT	Standard	ICEMODEL.BASE80.ESIM.DATA
5	Input	Main program	Standard	ICEMODEL.FIXED.FCOPT?.DATA
8	Output	CREATE6[b]	Sub.ENDOUT	ICEMODEL.?85.BTURTC.DATA
9	Input	Main program	Standard	ICEMODEL.FIXED.RYEAR85.DATA
10	Input	Main program	Standard	ICEMODEL.FIXED.RETRCOST.DATA
11	Input	Main program	CREATE6[a]	ICEMODEL.?.BLRPOP.DATA
13	Input	Main program	CREATE6[a]	ICEMODEL.?85.NUMCOL.DATA
14	Output	CREATE6[b]	Main program	ICEMODEL.?85.BLRAFC4.DATA
15	Input	Sub.FLSPEC	User	ICEMODEL.?.NSPSREGS.DATA
16	Output	CREATE6[b]	Sub.ENDOUT	ICEMODEL.?85.NUMCOL.DATA

[a]When "CY=85".

[b]When "CY=90".

market penetration rate for AFBC.

- ICEMODEL.FIXED.RETRCOST.DATA (see Table 3-8) stores the industrial boiler retrofit capital cost estimates.
- ICEMODEL.?XX.NUMCOL.DATA (see Table 3-12) tracks the total number of industrial plants with coal-burning experience.
- ICEMODEL.?.BLRPOP.DATA (see Table 3-9) contains details on the characteristics of new and existing industrial boilers.

Figures 2-3 and 2-4 show all of the subroutines called by the FLCH6 control program.

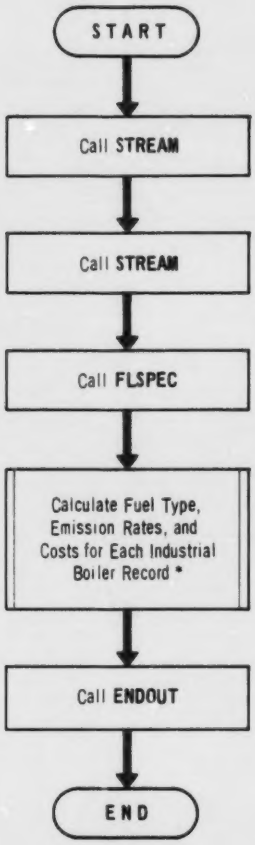
Subroutine STREAM (see Figure 2-3) reads the projected industrial fuel prices from ICEMODEL.?.DEMSCEN.DATA, an ICE Model user-created file. Subroutine FLSPEC reads the industrial coal type characteristics (sulfur, ash and Btu content) from ICEMODEL.?.DEMSCEN.DATA and the NSPS assumptions from ICEMODEL.?.NSPSREGS.DATA, an ICE Model user-created file. The fuel type specifications (sulfur, ash and Btu content) for natural gas, distillate fuel oil and the four residual fuel oil types are located in subroutine FLSPEC.

Subroutine ENDOUT writes the ESIM data to ICEMODEL.?.ESIM.DATA.

Subroutine STEAM (see Figure 2-4) calls subroutines STEMGD and STEMCL. STEMGD contains the capital and annual non-fuel O&M cost algorithms for new industrial natural gas, distillate fuel oil and residual fuel oil boilers (excluding pollution control equipment). STEMCL includes the industrial coal-fired boiler (excluding pollution control equipment) capital and annual non-fuel O&M cost algorithms.

Subroutines GDPOL, RESID and COAL each call several other subroutines (see Figure 2-5). Subroutine FGDRM calls subroutine FGDCAL. FGDCAL contains the capital and annual O&M cost algorithms for industrial boiler FGD equipment. PMRM calls subroutine PMCAL, the subroutine which includes industrial boiler PM emissions control equipment capital and annual O&M cost algorithms. NOXRM calls subroutine NOXCAL where the NO_X emissions control equipment capital and annual O&M cost algorithms are located.

Subroutine RESID compares the total costs for each of the four residual fuel oil types and selects the least-cost (after-tax net present value of total capital, O&M and fuel costs) residual fuel oil type. Subroutine COAL compares



Read Industrial Oil & Gas Price Projections and Calculate After-Tax NPV.

Read Industrial Coal Price Projections and Calculate After-Tax NPV.

Read Coal Type and NSPS Specifications; Define Specifications for Natural Gas & Oil Types.

Write ESIM file.

** Refer to Figure 2–4*

Figure 2–3. FLCH6 PGM.

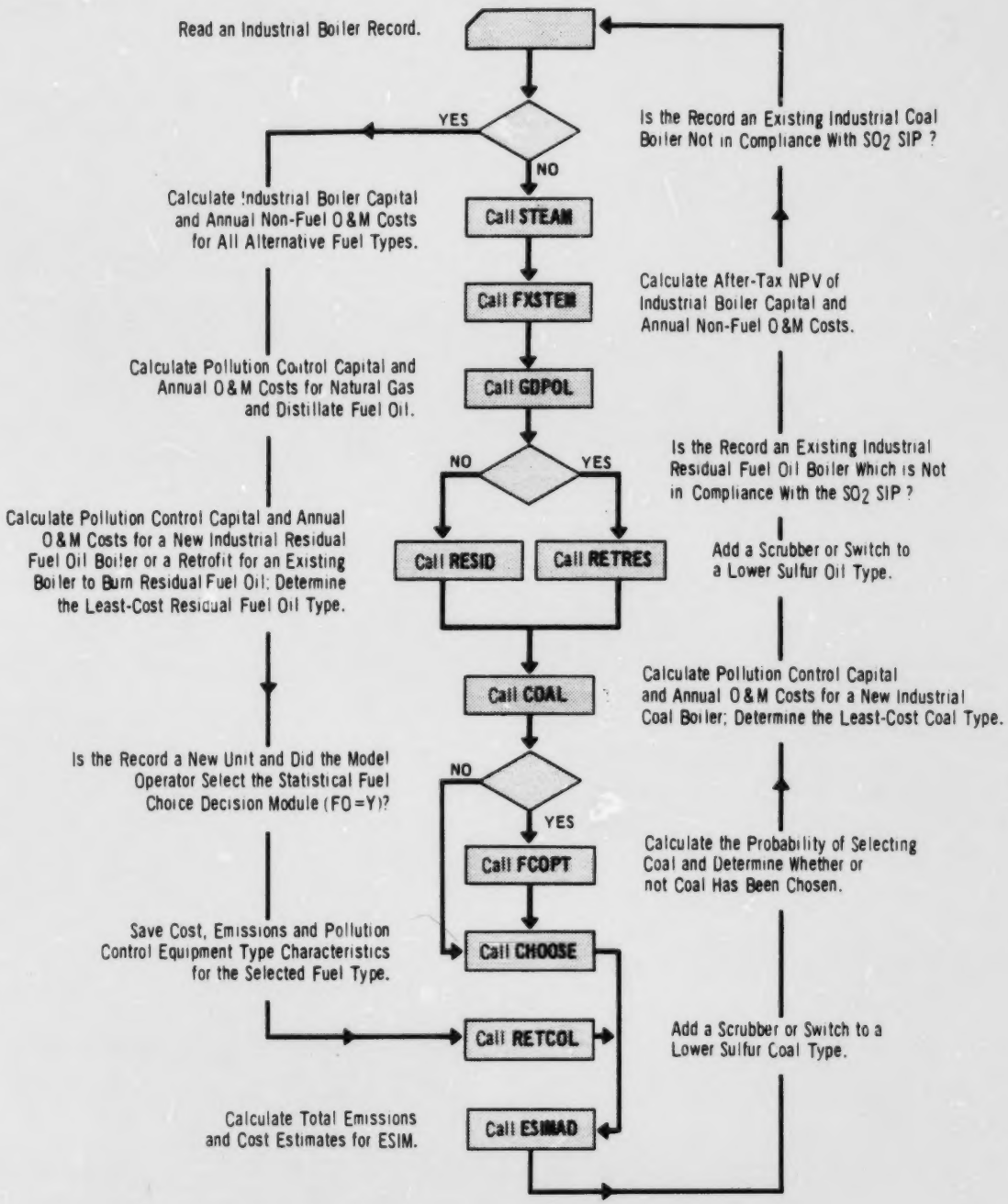

Read an Industrial Boiler Record.
YES
NO
Is the Record an Existing Industrial Coal Boiler Not in Compliance With SO_2 SIP ?
Calculate Industrial Boiler Capital and Annual Non-Fuel O&M Costs for All Alternative Fuel Types.
Call STEAM
Call FXSTEM
Calculate After-Tax NPV of Industrial Boiler Capital and Annual Non-Fuel O&M Costs.
Calculate Pollution Control Capital and Annual O&M Costs for Natural Gas and Distillate Fuel Oil.
Call GDPOL
NO
YES
Is the Record an Existing Industrial Residual Fuel Oil Boiler Which is Not in Compliance With the SO_2 SIP ?
Calculate Pollution Control Capital and Annual O&M Costs for a New Industrial Residual Fuel Oil Boiler or a Retrofit for an Existing Boiler to Burn Residual Fuel Oil; Determine the Least-Cost Residual Fuel Oil Type.
Call RESID
Call RETRES
Add a Scrubber or Switch to a Lower Sulfur Oil Type.
Call COAL
Calculate Pollution Control Capital and Annual O&M Costs for a New Industrial Coal Boiler; Determine the Least-Cost Coal Type.
Is the Record a New Unit and Did the Model Operator Select the Statistical Fuel Choice Decision Module (FO=Y)?
NO
YES
Call FCOPT
Calculate the Probability of Selecting Coal and Determine Whether or not Coal Has Been Chosen.
Save Cost, Emissions and Pollution Control Equipment Type Characteristics for the Selected Fuel Type.
Call CHOOSE
Call RETCOL
Add a Scrubber or Switch to a Lower Sulfur Coal Type.
Calculate Total Emissions and Cost Estimates for ESIM.
Call ESMAD

Figure 2–4. Fuel type selection in FLCH6 PGM.

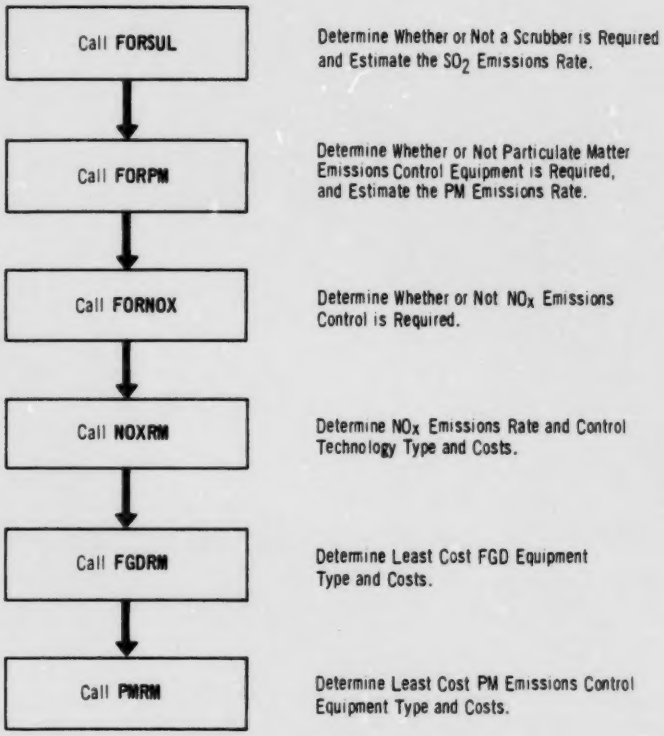

Call FORSUL
Determine Whether or Not a Scrubber is Required and Estimate the SO_2 Emissions Rate.
Call FORPM
Determine Whether or Not Particulate Matter Emissions Control Equipment is Required, and Estimate the PM Emissions Rate.
Call FORNOX
Determine Whether or Not NO_x Emissions Control is Required.
Call NOXRM
Determine NO_x Emissions Rate and Control Technology Type and Costs.
Call FGDRM
Determine Least Cost FGD Equipment Type and Costs.
Call PMRM
Determine Least Cost PM Emissions Control Equipment Type and Costs.

Figure 2–5. GDPOL, RESID and COAL subroutines in FLCH6 PGM.

the total costs for up to nine coal types and selects the least-cost (after-tax net present value of total capital, O&M and fuel costs) coal alternative.

Flowcharts for subroutines RESID, COAL, and FCOPT are presented in Appendix C.

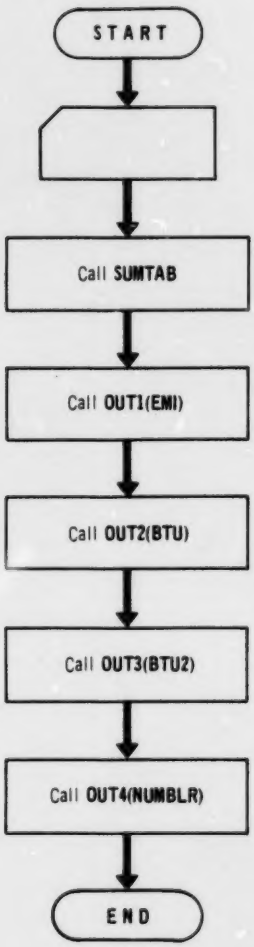
The FLCH6 control program writes output data for each industrial boiler record to ICEMODEL.?XX.BLRAFC4.DATA, an input file for the TABLE6 and CREATE6 programs.

TABLE6

The TABLE6 program prints aggregate ICE Model projections for industrial fossil fuel-fired boilers by year (1980 base year, 1985, 1990, 1995, 2000, 2010, 2020, and 2030), including:

- SO_2 emissions by State
- NO_x emissions by State
- Sulfate emissions by State
- Particulate matter (PM) emissions by State
- Total annualized costs by State
- Fuel demand by fuel type and State for all industrial boilers
- Fuel demand for new industrial boilers by fuel type and State
- National fuel demand for new industrial boilers by size (8 categories), annual capacity utilization rate (5 categories) and fuel type
- National number of new industrial boilers by size group (3 classes), previous coal experience (with or without) and fuel type.

The TABLE6 control program reads eight ICEMODEL.?XX.BLRAFC4.DATA files and the ICEMODEL.?.ESIM.DATA file. Figure 2-6 lists the subroutines called by the TABLE6 control program. There are almost 500 lines of source code in TABLE6.



Read Industrial Boiler Records and Add Results.

Calculate Subtotals and Totals.

Write Emissions and Cost Output Tables.

Write Fuel Mix Output Tables for All Industrial Boilers.

Write Fuel Mix Output Tables Only for New Industrial Boilers.

Write Additional Fuel Mix Output Tables Only for New Industrial Boilers.

Figure 2–6. TABLE6 PGM.

SECTION 3

DATA FILES

Table 3-1 lists the ICE Model data files which are summarized in this section. Several files are permanent input files (those with the same second qualifier in the file name, "FIXED"). Other permanent input files include:

- ICEMODEL.BASE80.BLRAFC4.DATA
- ICEMODEL.BASE80.BTUPOP.DATA
- ICEMODEL.BASE80.BTURTC.DATA
- ICEMODEL.BASE80.NUMCOL.DATA.

File descriptions are presented in Tables 3-2 through 3-12.* JCL unit numbers are summarized in Tables 2-1 and 2-2. None of the files presented in this section are created by the user. As noted in Tables 2-1 and 2-2, they are standard input files or they are created by CREATE6 or FLCH6. The purpose of these files and the data they contain are summarized in Section 2.

---

* The "?" in these file names is defined by the model operator in JCL. "XX" is the run year (see Table 3-7).

TABLE 3-1. ICE MODEL DATA FILES

File name	Record length (bytes)	Block size (bytes)
ICEMODEL.FIXED.AQCRCDF.DATA	80	2,960
ICEMODEL.FIXED.FCOPTN.DATA	80	6,160
ICEMODEL.FIXED.FCOPTY.DATA	80	2,960
ICEMODEL.FIXED.NEWSIPS2.DATA	80	2,960
ICEMODEL.FIXED.SIZCUDIS.DATA	80	2,960
ICEMODEL.FIXED.RYEARXX.DATA	20	6,220
ICEMODEL.FIXED.RETRCOST.DATA	80	2,960
ICEMODEL.?.BLRPOP.DATA[a]	151	15,800
ICEMODEL.?XX.BTUPOP.DATA[b]	80	8,000[c]
ICEMODEL.?XX.BLRAFC4.DATA[d]	158	15,800
ICEMODEL.?XX.BTURTC.DATA[d]	80	8,000[c]
ICEMODEL.?XX.NUMCOL.DATA[d]	80	8,000[e]

[a]This file is created during the execution of the CREATE6 program and "?" is replaced by a user-specified value.

[b]This file is a permanent input file when "?XX" = BASE80. Otherwise, this file is a new file created during the execution of the CREATE6 program and "?" is replaced by a user-specified value.

[c]2,960 when "?XX" = BASE80.

[d]This file is a permanent input file when "?XX" = BASE80. Otherwise, this file is a new file created during the execution of the FLCH6 program and "?" is replaced by a user-specified value.

[e]6,660 when "?XX" = BASE80.

TABLE 3-2. FILE DESCRIPTION: AQCRCDF[a]

Variable/array name	Comments
IST	State[b]
AQRDST(IST,101,1)	Number of AQCR's in the State
AQRDST(IST,I,1)[c]	AQCR number (1-243) if I <101
AQRDST(IST,I,2)[c]	Cumulative distribution function[d]

[a]Air Quality Control Region (AQCR) cumulative distribution function. Read free-format in CREATE6 program to assign new industrial boilers to an AQCR.

SOURCE: Fossil Fuel Demand for Stationary-Source Combustion and Other Selected Data for Each State and Air Quality Control Region, The Mitre Corporation, April 1975.

[b]Reference Table 3-14.

[c]I = 1 to the total number of AQCR's in the State, the value of AQRDST(IST,101,1).

[d]If I = AQRDST(IST,101,1) then AQRDST(IST,I,2) = 1.0. If I is less than AQRDST(IST,101,1), then AQRDST(IST,I,2) is greater than zero and less than 1.0.

TABLE 3-3. FILE DESCRIPTION: FCOPTN

Variable name	Comments
IFCOPT	"0"[a]

[a]Fuel choice option for new industrial boilers is the least-cost approach, not the statistical fuel choice decision module. Read free-format in FLCH6 program. This is not the standard operating procedure; this is used when the user selects the option "FO=N" in the JCL.

TABLE 3-4. FILE DESCRIPTION: FCOPTY

Variable name	Comments
IFCOPT	"1"[a]

[a]Fuel choice option for new industrial boilers is the statistical fuel choice decision module (that is, the probability of selecting coal is a function of boiler size, previous coal experience, and capital, O&M and fuel cost estimates), not the least-cost approach. Read free-format in FLCH6 programs. This is the standard operating procedure and is used when the user selects the option "FO=Y" in the JCL.

TABLE 3-5. FILE DESCRIPTION: NEWSIPS2[a]

Array name	Comments
SIPEQU(I,ISIPSZ,IAQCR,L,K)	K = 1, SO_2 SIP
	K = 2, PM SIP
	K = 3, NO_x SIP
	L = 1, coal
	L = 2, residual fuel oil
	IAQCR = 1-243
	ISIPSZ = 1, <100 MMBtu/hr
	ISIPSZ = 2, 100-250 MMBtu/hr
	ISIPSZ = 3, >250 MMBtu/hr
	I = 1, A
	I = 2, B
	I = 3, C (lb/MMBtu)

[a]State Implementation Plan air emissions regulations for industrial boilers. Emission regulations are calculated as (A * (size ** B)) + C, where size is expressed in MMBtu/hr. If A = B = 0 and C = 999.9, there is no SIP. Read free-format in CREATE6 program. Source: Energy and Environmental Analysis, Inc.

TABLE 3-6. FILE DESCRIPTION: SIZCUDIS[a]

Variable/array name	Comments
ISIC	Industry group (1-7)[b]
BLRDST(ISIC,41,1)	Number of records for each industry group
BLRDST(ISIC,I,1)[c]	Size (MMBtu/hr) if I<41
BLRDST(ISIC,I,2)[c]	Annual capacity utilization rate (percentage)
BLRDST(ISIC,I,3)[c]	Fraction[d]

[a]Distribution of new industrial boiler size and annual capacity utilization rates by industry group. Read free-format in CREATE6 program. Source: Energy and Environmental Analysis, Inc.

[b]Reference Table 3-13.

[c]I = 1 to the total number of records for each industry group.

[d] $\sum_{I}$ BLRDST(ISIC,I,3) = 1.0.

TABLE 3-7. FILE DESCRIPTION: RYEARXX[a]

Variable name	Comments
IYEAR or NYEAR	Run year[b]
PERIOD	Number of years between the current run year and the previous run year (5 or 10)
RFBC	Average market penetration of AFBC as a fraction of total new coal boilers with SO_2 emissions control equipment[c]

[a]XX = 85, 90, 95, 00, 10, 20, or 30; read free-format in CREATE6 and in FLCH6 programs.

[b]1985, 1990, 1995, 2000, 2010, 2020, or 2030.

[c]Currently set equal to zero (default); may be revised by the user.

TABLE 3-8. FILE DESCRIPTION: RETRCOST[a]

Array name	Comments
RETCAP(J,K,ICU,ISZ)	ISZ is boiler size class; ISZ = 1-7[b] ICU is capacity utilization rate class; ICU = 1-5[c] K denotes whether or not the boiler is an existing coal-capable unit and the current fuel type; K = 1-6[d] J denotes the new fuel type (J=1: natural gas, J=2: residual fuel oil, J=3: distillate fuel oil, J=4 or 5: coal)

[a]Industrial boiler retrofit capital costs (1978 $/MMBtu). Excludes pollution control equipment. Read free-format in FLCH6 program; used in subroutine STEAM. Source: Energy and Environmental Analysis, Inc.

[b]ISZ = 1, <30 MMBtu/hr
= 2, 30-50 MMBtu/hr
= 3, 50-75 MMBtu/hr
= 4, 75-100 MMBtu/hr
= 5, 100-175 MMBtu/hr
= 6, 175-250 MMBtu/hr
= 7, >250 MMBtu/hr

[c]ICU = 1, 25 percent
= 2, 45 percent
= 3, 55 percent
= 4, 65 percent
= 5, 75 percent

[d]K = 1, coal-capable/natural gas
= 2, coal-capable/residual fuel oil
= 3, coal-capable/distillate fuel oil
= 4, not coal-capable/natural gas
= 5, not coal-capable/residual fuel oil
= 6, not coal-capable/distillate fuel oil

TABLE 3-9. FILE DESCRIPTION: BLRPOP[a] AND BLRAFC4[b]

Variable name	Positions	Format	Comments
ISIZE	1-3	I3	MMBtu/hr
ICU	4-5	I2	Annual capacity utilization rate (percentage)
IFUEL	6-8	I3	Fuel type[c]
ISEC or JSEC	9	I1	Sector[d]
ILIFE or JYR	10-11	I2	Years
DUALFR	12	A1	Dual fuel-firing capability[c]
ICLBLR or IBLRTP	13	I1	Coal boiler type[c]
IPRCL or IPRCLX	14	I1	Previous coal experience (1=yes; 0=no)
IBTUS	15-24	I10	Million Btu, annual fuel consumption[e]
ISIC	25	I1	Industry group[c]
IST	26-27	I2	State[f]
IAQCR	28-30	I3	Air Quality Control Region number (1-243)
ISIPS(K,L), L=1-2 K=1-3; or IREGU(I), I=1-6	31-48	6I3	State Implementation Plan SO_2, PM, and NO_x emissions limits for industrial residual fuel oil and coal boilers[g]; units: (lb/MMBtu) * 100
IRAN6D	49-54	I6	Random number
IBLRCS(I), I=1-2	55-62	2I4	Industrial boiler (excluding pollution control equipment) capital and annual non-fuel O&M costs; units: (1978 $/MMBtu) * 100

(continued)

TABLE 3-9. (Continued)

Variable name	Positions	Format	Comments
FUELPR(1)	63-68	F6.2	Industrial fuel price, after-tax present value; units: 1978 $/MMBtu
FUELPR(2)	69-73	F5.2	Industrial fuel price for the run year; units: 1978 $/MMBtu
IPOLUT(I,J), I=1-3; J-1-4	74-145	12I6	Data on emission rates and pollution control equipment types and costs[h]
SO4EMI	146-151	F6.4	Sulfates emission rate (lb/MMBtu)
SALLOW	152-157	I6	"Allowable" SO_2 emission rate: (lb/MMBtu) * 10^4

[a]Industrial boiler characteristics for each record in the projected "population." Created in CREATE6 program and used as an input file to FLCH6 program. A long file (over 100 tracks).

[b]Industrial boiler characteristics for each record in the "population." Created in FLCH6 program, used as an input file in the next period's CREATE6 program, and used as an input file in TABLE6. However, the TABLE6 program uses a slightly different format statement and slightly different variable names for this file. "ICEMODEL.BASE80.BLRAFC4.DATA" is a permanent input file for the 1985 CREATE6 program; source: Energy and Environmental Analysis, Inc.

[c]Reference Table 3-13.

[d]ISEC or JSEC = 1, existing coal-capable industrial boiler which is burning oil or gas
= 2, existing non-coal-capable industrial boiler
= 3, new industrial boiler
= 4, new industrial boiler installed between 1980 and 1985
= 5, new industrial boiler installed after 1985

[e]Integer multiple of (ISIZE * ICU * 8,760/100). There may be more than one boiler on each record.

[f]Reference Table 3-14.

[g]Labeled IREGU(I),I=1-6 in FLCH6 program. Labeled ISIPS(K,L) in CREATE6 program.

[h]Reference Table 3-15. This array name is POLSPC in TABLE6 program.

TABLE 3-10. FILE DESCRIPTION: BTUPOP[a]

Array name	Comments
BASEOG(ISIC,IST)	Total current oil and gas consumption in industrial boilers existing in the base year (currently 1980) by industry group and State
BASECL(ISIC,IST)	Total current coal consumption in industrial boilers existing in the base year (currently 1980) by industry group and State
CUMNW(ISIC,IST)	Total current fossil fuel consumption in industrial boilers installed after the base year (currently 1980) by industry group and State

[a]Units: million Btu. Used in retirement calculations in CREATE6 program. "ICEMODEL.BASE80.BTUPOP.DATA" is a permanent input file for the 1985 CREATE6 program; source: Energy and Environmental Analysis, Inc.

TABLE 3-11. FILE DESCRIPTION: BTURTC[a]

Array name	Comments
BTURTC[b] or RETROC[c] or IRETCL[d] or BASERC[e] (ISIC,IST)	Units: million Btu. Aggregated by industry group and State

[a]Retrofits to coal from existing coal-capable industrial boilers which are currently burning oil or gas. "ICEMODEL.BASE80.BTURTC.DATA" is a permanent input file for the 1985 CREATE6 program; all values in this file equal zero.

[b]Written in subroutine ENDOUT in FLCH6 program.

[c]Read in subroutine INPUT in CREATE6 program.

[d]Aggregated at the end of the main program in FLCH6 program.

[e]Used in subroutine DEMAND in CREATE6 program.

TABLE 3-12. FILE DESCRIPTION: NUMCOL[a]

Variable name	Comments
NUMCOL(I)	I = 1: Federal regions 1, 2, 6, 7, 8, 9, and 10[b]
	I = 2: Federal regions 3, 4, and 5[b]

[a]Number of industrial plants with previous coal-burning experience. Read free-format in CREATE6 program and written free-format in FLCH6 program. "ICEMODEL.BASE80.NUMCOL.DATA" is a permanent input file for the 1985 CREATE6 program; source: Energy and Environmental Analysis, Inc.

[b]Reference Figure 3-1.

REGION NAMES

1. New England
2. New York/New Jersey
3. Middle Atlantic
4. South Atlantic
5. Midwest
6. Southwest
7. Central
8. North Central
9. West
10. Northwest

Figure 3–1. Federal regions of the United States.

TABLE 3-13. DEFINITIONS OF SELECTED VARIABLES[a]

Variable name	Possible values	Definition
IFUEL	100	Natural gas
	200	Distillate fuel oil
	301	Residual fuel oil, 3.0 percent sulfur
	302	Residual fuel oil, 1.6 percent sulfur
	303	Residual fuel oil, 0.8 percent sulfur
	304	Residual fuel oil, 0.3 percent sulfur
	402	Bituminous coal, <1.08 lb SO_2/MMBtu[b]
	403	Bituminous coal, 1.08-1.67 lb SO_2/MMBtu[b]
	404	Bituminous coal, 1.67-2.50 lb SO_2/MMBtu[b]
	405	Bituminous coal, 2.50-3.33 lb SO_2/MMBtu[b]
	406	Bituminous coal, 3.33-5.00 lb SO_2/MMBtu[b]
	407	Bituminous coal, >5.00 lb SO_2/MMBtu[b]
	409	Subbituminous coal, <1.08 lb SO_2/MMBtu[b]
	410	Subbituminous coal, 1.08-1.67 lb SO_2/MMBtu[b]
	411	Subbituminous coal, 1.67-2.50 lb SO_2/MMBtu[b]
DUALFR	0	Single fuel
	1	Natural gas/residual fuel oil
	2	Natural gas/distillate fuel oil
	3	Natural gas/coal
	4	Residual fuel oil/coal
	5	Distillate fuel oil/coal
	6	Natural gas/residual fuel oil/coal
	7	Natual gas/distillate fuel oil/coal
	8	Distillate fuel oil/residual fuel oil/coal
	9	Distillate fuel oil/residual fuel oil
	A	Distillate fuel oil/residual fuel oil/ natural gas
	B	Distillate fuel oil/residual fuel oil/ natural gas/coal
ICLBLR or IBLRTP	1	Underfeed stoker
	2	Spreader stoker
	3	Pulverized coal
	4	Atmospheric fluidized bed combustion
ISIC	1	Food
	2	Textiles
	3	Paper
	4	Chemicals
	5	Petroleum refining
	6	Primary metals
	7	Other

[a]Supplement to Table 3-9.

[b]Subject to change by ICE Model user in input file ICEMODEL.?.DEMSCEN.DATA.

TABLE 3-14. STATE CODES[a]

State	Code[b]	State	Code[b]
Alabama	1	Montana	26
Alaska	2	Nebraska	27
Arizona	3	Nevada	28
Arkansas	4	New Hampshire	29
California	5	New Jersey	30
Colorado	6	New Mexico	31
Connecticut	7	New York	32
Delaware	8	North Carolina	33
Florida	9	North Dakota	34
Georgia	10	Ohio	35
Hawaii	11	Oklahoma	36
Idaho	12	Oregon	37
Illinois	13	Pennsylvania	38
Indiana	14	Rhode Island	39
Iowa	15	South Carolina	40
Kansas	16	South Dakota	41
Kentucky	17	Tennessee	42
Louisiana	18	Texas	43
Maine	19	Utah	44
Maryland/District of Columbia	20	Vermont	45
Massachusetts	21	Virginia	46
Michigan	22	Washington	47
Minnesota	23	West Virginia	48
Mississippi	24	Wisconsin	49
Missouri	25	Wyoming	50

[a]Supplement to Tables 3-2 and 3-9.

[b]Variable "IST".

TABLE 3-15. IPOLUT[a]

Array name	Units	Definition
IPOLUT(1,1)	(lb/MMBtu) * 10^4	SO_2 emission rate
IPOLUT(2,1)	(1 - 5) * 10^4	FGD system type[b]
IPOLUT(3,1)	(1978 $/MMBtu) * 10^4	FGD system capital cost[b]
IPOLUT(4,1)	(1978 $/MMBtu) * 10^4	FGD system O&M cost[b]
IPOLUT(1,2)	(lb/MMBtu) * 10^4	PM emission rate
IPOLUT(2,2)	(1 - 7) * 10^4	PM emissions control equipment type[c]
IPOLUT(3,2)	(1978 $/MMBtu) * 10^4	PM emissions control equipment capital cost[c]
IPOLUT(4,2)	(1978 $/MMBtu) * 10^4	PM emissions control equipment O&M cost[c]
IPOLUT(1,3)	(lb/MMBtu) * 10^4	NO_x emission rate
IPOLUT(2,3)	(1 or 2) * 10^4	NO_x emissions control equipment type[d]
IPOLUT(3,3)	(1978 $/MMBtu) * 10^4	NO_x emissions control equipment capital cost[d]
IPOLUT(4,3)	(1978 $/MMBtu) * 10^4	NO_x emissions control equipment O&M cost[d]

[a]Supplement to Table 3-9. This array name is POLSPC in TABLE6 program.

[b]Reference subroutine FGDCAL in FLCH6 program.

[c]Reference subroutine PMCAL in FLCH6 program.

[d]Reference subroutine NOXCAL in FLCH6 program.

SECTION 4

INTERNAL VARIABLES

This section describes the major computer program variables which are used in CREATE6, FLCH6, and TABLE6 programs (which are not defined in Section 3, Data Files). These variables are presented in this section by program. See Appendix A for an index of these variable names. Major constants are described in Section 5.

Variable name:	**COALRT** or **XKEPCL**
Variable type:	Array, dimensioned 7 by 50
Program:	CREATE6
Accessed by:	Subroutines DEMAND, RETIRE
Description:	COALRT(ISIC,IST) or XKEPCL(ISIC,IST) is the fraction of remaining annual coal consumption in the base year industrial boilers which will be retained (not retired) in the run year by industry group (ISIC=1-7) and State (IST=1-50).
Units:	Dimensionless number

Variable name:	**CURBTU** or **TOTDEM**
Variable type:	Array, dimensioned 7 by 50
Program:	CREATE6
Accessed by:	Subroutines INPUT, DEMAND, CREATE
Description:	CURBTU(ISIC,IST) or TOTDEM(ISIC,IST) is the total projected annual fossil fuel demand in industrial boilers by industry group (ISIC=1-7) and State (IST=1-50). This is read from input file ICEMODEL.?.DEMSCEN.DATA, a user-specified file.
Units:	Million Btu

Variable name:	**ISIPS**
Variable type:	Array, dimensioned 3 by 2
Program:	CREATE6
Accessed by:	Subroutines RETIRE, CREATE
Description:	ISIPS(K,L) is the State Implementation Plan (SIP) air emission limits by fuel type and pollutant (L=1, coal; L=2, residual fuel oil; K=1, SO_2; K=2, PM; K=3, NO_x). Labeled IREGU(J), J=1-6 in FLCH6 program.
Units:	(lb/MMBtu) * 100

Variable name:	**PRCLFR**
Variable type:	Vector, dimensioned 2
Program:	CREATE6
Accessed by:	Subroutines INPUT, CREATE
Description:	PRCLFR(I) is the estimated fraction of industrial plants with previous coal-burning experience in Federal regions 1, 2, 6, 7, 8, 9, and 10 (I=1) and in Federal regions 3, 4, and 5 (I=2). The Federal regions are illustrated in Figure 3-1.
Units:	Dimensionless number

Variable name:	**TBTUS**
Variable type:	Array, dimensioned 7 by 50
Program:	CREATE6
Accessed by:	Subroutines RETIRE, CREATE
Description:	TBTUS(ISIC,IST) is the total projected annual fossil fuel demand in existing industrial boilers (after retirement) by industry group (ISIC=1-7) and State (IST=1-50).
Units:	Million Btu

Variable name:	**XCL85,XCL90** or **XCL95**
Variable type:	Array, dimensioned 7 by 50
Program:	CREATE6
Accessed by:	Subroutine DEMAND
Description:	XCL85(ISIC,IST), XCL90(ISIC,IST) and XCL95(ISIC,IST) are the projected values for BASECL(ISIC,IST) after retirement in 1985, 1990 and 1995, respectively (reference Table 3-10).
Units:	Million Btu

Variable name:	**XGRATE** or **XKEPOG**
Variable type:	Array, dimensioned 7 by 50
Program:	CREATE6
Accessed by:	Subroutines DEMAND, RETIRE
Description:	XGRATE(ISIC,IST) or XKEPOG(ISIC,IST) is the fraction of remaining annual natural gas, distillate and residual fuel oil consumption in base year industrial boilers which will be retained (not retired) in the run year by industry group (ISIC=1-7) and State (IST=1-50).
Units:	Dimensionless number

Variable name:	**XNEW85, XNEW90** or **XNEW95**
Variable type:	Array, dimensioned 7 by 50
Program:	CREATE6
Accessed by:	Subroutine DEMAND
Description:	XNEW85(ISIC,IST), XNEW90(ISIC,IST) and XNEW95(ISIC,IST) are the values for CUMNW(ISIC,IST) in 1985, 1990 and 1995, respectively (reference Table 3-10).
Units:	Million Btu

Variable name:	**XNEWNW**
Variable type:	Array, dimensioned 7 by 50
Program:	CREATE6
Accessed by:	Subroutine CREATE
Description:	XNEWNW(ISIC,IST) is the total projected annual fossil fuel demand in new industrial boilers by industry group (ISIC=1-7) and State (IST=1-50).
Units:	Million Btu

Variable name:	**XOG85, XOG90** or **XOG95**
Variable type:	Array, dimensioned 7 by 50
Program:	CREATE6
Accessed by:	Subroutine DEMAND
Description:	XOG85(ISIC,IST), XOG90(ISIC,IST) and XOG95(ISIC,IST) are the values for BASEOG(ISIC,IST) after retirement in 1985, 1990 and 1995, respectively (reference Table 3-10).
Units:	Million Btu

Variable name:	**ICODE**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines RETCOL, GDPOL, RESID, RETRES, COAL, FGDRM, PMRM, NOXRM, FGDCAL, PMCAL, NOXCAL
Description:	ICODE is the fuel type: ICODE = 1, natural gas ICODE = 2, distillate fuel oil ICODE = 3, residual fuel oil ICODE = 4, coal
Units:	Dimensionless number
Storage location:	COMMON/DUMMY/

Variable name:	**IREGU**
Variable type:	Vector, dimensioned 6
Program:	FLCH6
Accessed by:	Subroutines FORSUL, FORPM, FORNOX
Description:	IREGU(J) is the State Implementation Plan air emission limits by fuel type and pollutant: J = 1, coal SO_2 J = 2, coal PM J = 3, coal NO_x J = 4, residual fuel oil SO_2 J = 5, residual fuel oil PM J = 6, residual fuel oil NO_x Labeled ISIPS(K,L), L=1-2, K=1-3 in CREATE6 program.
Units:	(lb/MMBtu) * 100
Storage location:	COMMON/BK05/

Variable name: ICOL

Variable type: Scalar

Program: FLCH6

Accessed by: Subroutines COAL, STEAM, FLSPEC, CHOOSE

Description: ICOL is the industrial coal type. ICOL=1-110, 11 types per Federal region (defined by user in input file ICEMODEL.?.DEMSCEN.DATA) by ten Federal regions (see Figure 3-1).

Units: Dimensionless number

Variable name: IRES

Variable type: Scalar

Program: FLCH6

Accessed by: Subroutines RESID, RETRES, CHOOSE

Description: IRES is the industrial residual fuel oil type:

IRES = 1, 3.0 percent sulfur
IRES = 2, 1.6 percent sulfur
IRES = 3, 0.8 percent sulfur
IRES = 4, 0.3 percent sulfur

Units: Dimensionless number

Variable name:	**CAPCOL**
Variable type:	Vector, dimensioned 150
Program:	FLCH6
Accessed by:	Subroutines STEAM, COAL
Description:	CAPCOL(I) is the industrial coal-fired boiler (excluding pollution control equipment) capital cost estimate by coal type (I=1-110; 11 per Federal region, defined by user in input file ICEMODEL.?.DEMSCEN.DATA; I=111-150 is not used).
Units:	1978 $/MMBtu
Storage location:	COMMON/BK18/

Variable name:	**OMCOL**
Variable type:	Vector, dimensioned 150
Program:	FLCH6
Accessed by:	Subroutines STEAM, COAL
Description:	OMCOL(I) is the industrial coal-fired boiler (excluding pollution control equipment) annual non-fuel operating and maintenance cost estimate for each coal type (I=1-110, as noted above for CAPCOL; I=111-150 is not used).
Units:	1978 $/MMBtu
Storage location:	COMMON/BK18/

Variable name:	**BCAPT**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines COAL, CHOOSE
Description:	BCAPT is the industrial coal-fired boiler (excluding pollution control equipment) or AFBC capital cost estimate.
Units:	1978 $/MMBtu
Storage location:	COMMON/BK18/

Variable name:	**BOM**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine COAL, CHOOSE
Description:	BOM is the industrial coal-fired boiler (excluding pollution control equipment) annual non-fuel operating and maintenance cost estimate.
Units:	1978 $/MMBtu
Storage location:	COMMON/BK18/

Variable name:	**SUL**
Variable type:	Vector, dimensioned 150
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, RETCOL, COAL, CHOOSE, FORSUL
Description:	SUL(ICOL) is the uncontrolled SO_2 emission rate for each coal type (ICOL=1-110; 11 per Federal region; ICOL=111-150 is not used).
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/BK01/

Variable name:	**PMC**
Variable type:	Vector, dimensioned 150
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, COAL, FORPM
Description:	PMC(ICOL) is the total ash content for each coal type (ICOL=1-110; 11 per Federal region; ICOL=111-150 is not used).
Units:	(lb PM/MMBtu) * 100
Storage location:	COMMON/BK01/

Variable name:	**ASH**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines COAL, PMCAL
Description:	ASH is the ash content of a specific coal type
Units:	Percentage
Storage location:	COMMON/DUMMY/

Variable name:	**PM**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines COAL, PMCAL
Description:	PM is the controlled particulate matter emission rate for a specific fuel type.
Units:	(lb PM/MMBtu) * 100
Storage location:	COMMON/DUMMY/

Variable name:	**REDSUL**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines RESID, COAL, FGDCAL
Description:	REDSUL is the required SO_2 emissions reduction rate for a specific fuel type and boiler record.
Units:	Percentage
Storage location:	COMMON/DUMMY/

Variable name:	**SULF**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines RESID, COAL, FGDCAL, PMCAL
Description:	SULF is the sulfur content of the delivered (unburned) fuel type.
Units:	Percentage
Storage location:	COMMON/DUMMY/

Variable name:	BT
Variable type:	Vector, dimensioned 150
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, RETCOL, COAL, FORSUL, FORPM, FORNOX
Description:	BT(ICOL) is the Btu or heat content for each coal type (ICOL=1-110; 11 per Federal region, defined by user in input file ICEMODEL.?.DEMSCEN.DATA; ICOL=111-150 is not used).
Units:	Btu/pound
Storage location:	COMMON/BK01/

Variable name:	CLPRST
Variable type:	Array, dimensioned 11 by 10 by 70 by 3
Program:	FLCH6
Accessed by:	Subroutines STREAM, CHOOSE
Description:	CLPRST(ICOL2,REGION,YRNUM,ISEC or SECTOR) is the projected industrial coal prices by coal type (ICOL2=1-11, defined by the user in input file ICEMODEL.?.DEMSCEN.DATA), Federal region (REGION=1-10, reference Figure 3-1), year (YRNUM=1, 1980, to 70, 2049) and sector (ISEC or SECTOR=1-3).
Units:	1978 $/MMBtu

Variable name:	**FOB**
Variable type:	Array, dimensioned 11 by 10 by 15 by 3
Program:	FLCH6
Accessed by:	Subroutines STREAM, COAL, RETCOL, CHOOSE
Description:	FOB(ICOL2,REGION,PVYEAR,ISEC or SECTOR) is the after-tax present value of projected industrial coal prices by coal type (ICOL2=1-11, defined by the user in input file ICEMODEL.?.DEMSCEN.DATA), Federal region (REGION=1-10, reference Figure 3-1), number of years in the investment period (PVYEAR=1-15), and sector (ISEC or SECTOR=1-3).
Units:	1978 $/MMBtu (negative because fuel costs are an expense)

Variable name:	**CAPNEW**
Variable type:	Vector, dimensioned 4
Program:	FLCH6
Accessed by:	Subroutines STEAM, FXSTEM
Description:	CAPNEW(I) is the new industrial boiler (excluding pollution control equipment) capital cost estimate for natural gas (I=1), distillate fuel oil (I=2), and residual fuel oil (I=3). I=4 is not used.
Units:	1978 $/MMBtu
Storage location:	COMMON/BK07/

Variable name:	**OMNEW**
Variable type:	Vector, dimensioned 4
Program:	FLCH6
Accessed by:	Subroutines STEAM, FXSTEM
Description:	OMNEW(I) is the new industrial boiler (excluding pollution control equipment) annual non-fuel operating and maintenance cost estimate for natural gas (I=1), distillate fuel oil (I=2), and residual fuel oil (I=3). I=4 is not used.
Units:	1978 $/MMBtu
Storage location:	COMMON/BK07/

Variable name:	**OGPRST**
Variable type:	Array, dimensioned 11 by 10 by 70 by 3
Program:	FLCH6
Accessed by:	Subroutines STREAM, CHOOSE
Description:	OGPRST(FUEL,REGION,YRNUM,ISEC or SECTOR) is the projected industrial natural gas (FUEL=1), distillate fuel oil (FUEL=2), 3.0 percent sulfur residual fuel oil (FUEL=3), 1.6 percent sulfur residual fuel oil (FUEL=4), 0.8 percent sulfur residual fuel oil (FUEL=5), and 0.3 percent sulfur residual fuel oil (FUEL=6) price by Federal region (REGION=1-10; reference Figure 3-1), year (YRNUM=1, 1980, to 70, 2049) and sector (ISEC or SECTOR=1-3). FUEL=7-11 is not used.
Units:	1978 $/MMBtu

Variable name: **OTHR**

Variable type: Array, dimensioned 11 by 10 by 15 by 3

Program: FLCH6

Accessed by: Subroutines STREAM, GDPOL, RESID, RETRES, RETCOL, COAL, CHOOSE

Description: OTHR(FUEL,REGION,IYR or PVYEAR,SECTOR) is the after-tax present value of projected industrial oil and gas prices (FUEL=1-6, REGION=1-10, SECTOR=1-3 as above for OGPRST) by the number of years in the investment period (IYR or PVYEAR=1-15).

Units: 1978 $/MMBtu (negative because fuel costs are an expense)

Variable name: **CILSO2**

Variable type: Array, dimensioned 10 by 4

Program: FLCH6

Accessed by: Subroutines FLSPEC, FORSUL

Description: CILSO2(I,IFUEL) is the NSPS SO_2 "ceiling" emission rate, if the annual capacity utilization rate is larger than 30 percent, by fuel type (IFUEL=3, residual fuel oil; IFUEL=4, coal) and boiler size class (MMBtu/hr):

I = 1, <30	I = 5, 100-150
I = 2, 30-50	I = 6, 150-200
I = 3, 50-75	I = 7, 200-250
I = 4, 75-100	I = 8, >250

I = 9 or 10 is not used
IFUEL = 1-2 is not used.

Units: (lb SO_2/MMBtu) * 100

Storage location: COMMON/SPECS/

Variable name:	**SMSO2**
Variable type:	Array, dimensioned 10 by 4
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	SMSO2(I,IFUEL) is the NSPS SO_2 "ceiling" emission rate, if the annual capacity utilization rate is equal to or less than 30 percent, by fuel type and boiler size class (as above for CILSO2).
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**CILPM**
Variable type:	Array, dimensioned 10 by 4
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORPM
Description:	CILPM(I,IFUEL) is the NSPS PM emission rate, if the annual capacity utilization rate is larger than 30 percent, by fuel type and boiler size class (as for CILSO2).
Units:	(lb PM/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**SMPM**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORPM
Description:	SMPM(I) is the coal NSPS PM emission rate, if the annual capacity utilization rate is equal to or less than 30 percent, by boiler size class (as for CILSO2).
Units:	(lb PM/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**RSIFLR**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	RSIFLR(I) is the NSPS SO_2 "floor" emission rate for residual fuel oil, if the annual capacity utilization rate is greater than 30 percent, by boiler size class (as for CILSO2).
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**SFLR**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	SFLR(I) is the NSPS SO_2 "floor" emission rate for residual fuel oil, if the annual capacity utilization rate is equal to or less than 30 percent, by boiler size class (as for CILSO2).
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**RSIMND**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	RSIMND(I) is the recommended fuel oil NSPS SO_2 emission removal rate, if the annual capacity utilization rate is greater than 30 percent, by boiler size (as for CILSO2).
Units:	Percentage
Storage location:	COMMON/SPECS/

Variable name:	**SREC**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	SREC(I) is the recommended residual fuel oil NSPS SO_2 emission removal rate, if the annual capacity utilization rate is equal to or less than 30 percent, by boiler size (as for CILSO2).
Units:	Percentage
Storage location:	COMMON/SPECS/

Variable name:	**RSIMIN**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	RSIMIN(I) is the minimum residual fuel oil NSPS SO_2 emissions removal rate, if the annual capacity utilization rate is greater than 30 percent, by boiler size class (as for CILSO2).
Units:	Percentage
Storage location:	COMMON/SPECS/

Variable name:	**SMIN**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	SMIN(I) is the minimum residual fuel oil NSPS SO_2 emissions removal rate, if the annual capacity utilization rate is equal to or less than 30 percent, by boiler size class (as for CILSO2).
Units:	Percentage
Storage location:	COMMON/SPECS/

Variable name:	**EXLSR**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	EXLSR(I) is the low sulfur residual fuel oil exemption from a mandatory scrubbing NSPS, if the annual capacity utilization rate is greater than 30 percent, by boiler size class (as for CILSO2).
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**RLCU**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	RLCU(I) is the low sulfur residual fuel oil exemption from a mandatory scrubbing NSPS, if the annual capacity utilization rate is equal to or less than 30 percent, by boiler size class (as for CILSO2).
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**FLOOR**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	FLOOR(I) is the NSPS SO_2 "floor" emission rate for coal, if the annual capacity utilization rate is greater than 30 percent, by boiler size class (as for CILSO2).
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**CSFLR**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	CSFLR(I) is the NSPS SO_2 "floor" emissions rate for coal, if the annual capacity utilization rate is equal to or less than 30 percent, by boiler size class (as for CILSO2).
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**RECMND**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	RECMND(I) is the recommended coal NSPS SO_2 emissions removal rate, if the annual capacity utilization rate is greater than 30 percent, by boiler size class (as for CILSO2).
Units:	Percentage
Storage location:	COMMON/SPECS/

Variable name:	**CSREC**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	CSREC(I) is the recommended coal NSPS SO_2 emissions removal rate, if the annual capacity utilization rate is equal to or less than 30 percent, by boiler size class (as for CILSO2).
Units:	Percentage
Storage location:	COMMON/SPECS/

Variable name:	**RECMIN**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	RECMIN(I) is the minimum coal NSPS SO_2 emissions removal rate, if the annual capacity utilization rate is greater than 30 percent, by boiler size class (as for CILSO2).
Units:	Percentage
Storage location:	COMMON/SPECS/

Variable name:	**CSMIN**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	CSMIN(I) is the minimum coal NSPS SO_2 emissions removal rate, if the annual capacity utilization rate is equal to or less than 30 percent, by boiler size class (as for CILSO2).
Units:	Percentages
Storage location:	COMMON/SPECS/

Variable name:	**EXLSC**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	EXLSC(I) is the low sulfur coal exemption from a mandatory scrubbing NSPS, if the annual capacity utilization rate is greater than 30 percent, by boiler size class (as for CILSO2).
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**CLCU**
Variable type:	Vector, dimensioned 10
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	CLCU(I) is the low sulfur coal exemption from a mandatory scrubbing NSPS, if the annual capacity utilization rate is equal to or less than 30 percent, by boiler size class (as for CILSO2).
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/SPECS/

Variable name:	**RATE**
Variable type:	Vector, dimensioned 3
Program:	FLCH6
Accessed by:	Subroutines FORSUL, FORPM, FORNOX
Description:	RATE(1) is the pollutant percentage content of the delivered (unburned) fuel type. RATE(2) is the estimated air emission rate. RATE(3) is the required percentage reduction of air emissions.
Units:	RATE(1) = percentage RATE(2) = (lb/MMBtu) * 100 RATE(3) = percentage

Variable name:	**COSRES**
Variable type:	Vector, dimensioned 4
Program:	FLCH6
Accessed by:	Subroutines RESID, RETRES
Description:	COSRES(IFROM or ISTRT) is the total after-tax NPV of the capital, O&M and fuel costs (boiler and pollution control equipment) for the least-cost residual fuel oil type (IFROM=1-4, as for COSGAS).
Units:	1978 $/MMBtu (negative value)

Variable name:	**COSCOL**
Variable type:	Vector, dimensioned 4
Program:	FLCH6
Accessed by:	Subroutines COAL, FCOPT
Description:	COSCOL(IFROM or ISTRT) is the total after-tax NPV for the capital, O&M and fuel costs (boiler and pollution control equipment) for the least-cost coal type (IFROM=1-4, as for COSGAS).
Units:	1978 $/MMBtu (negative value)

Variable name:	**COSDIS**
Variable type:	Vector, dimensioned 4
Program:	FLCH6
Accessed by:	Subroutines GDPOL, CHOOSE
Description:	COSDIS(IFROM or ISTRT) is the total after-tax NPV of the capital, O&M and fuel costs (boiler and pollution control equipment) for distillate fuel oil (IFROM=1-4 as for COSGAS).
Units:	1978 $/MMBtu (negative value)

Variable name:	**COSGAS**
Variable type:	Vector, dimensioned 4
Program:	FLCH6
Accessed by:	Subroutines GDPOL, CHOOSE
Description:	COSGAS(IFROM or ISTRT) is the total after-tax NPV of the capital, O&M and fuel costs (boiler and pollution control equipment) for natural gas: IFROM = 1, existing natural gas boiler IFROM = 2, existing residual fuel oil boiler IFROM = 3, existing distillate fuel oil boiler IFROM = 4, new boiler
Units:	1978 $/MMBtu (negative value)

Variable name:	**COSMIN**
Variable type:	Vector, dimensioned 4
Program:	FLCH6
Accessed by:	Subroutines RESID, FCOPT
Description:	COSMIN(IFROM or ISTRT) is the total after-tax NPV of the capital, O&M and fuel costs (boiler and pollution control equipment) for the least-cost fuel oil type or natural gas (IFROM=1-4 as for COSGAS).
Units:	1978 $/MMBtu (negative value)

Variable name:	**COSDIF**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FCOPT
Description:	COSDIF is the total (capital, O&M and fuel) after-tax NPV for a new industrial boiler (including pollution control equipment) of the least-cost oil/gas alternative less the least-cost coal alternative.
Units:	1978 $/MMBtu

Variable name:	ABSDOL
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FCOPT
Description:	ABSDOL is the total (capital, O&M and fuel) after-tax NPV for a new industrial boiler (including pollution control equipment) of the least cost oil/gas alternative less the least-cost coal alternative.
Units:	Millions of 1978 dollars

Variable name:	CPX
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FCOPT
Description:	CPX is the probability of selecting coal as a new industrial boiler fuel type.
Units:	Dimensionless number

Variable name:	SEXP
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FCOPT
Description:	SEXP is a parameter in the linear regression equation which estimates the probability of selecting coal as a new industrial boiler fuel type.
Current values:	1, if boiler size is less than 100 MMBtu/hr and if the plant is expected to have previous coal experience. 0, otherwise
Units:	Dimensionless number

Variable name:	AMEXP
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FCOPT
Description:	AMEXP is a parameter in the linear regression equation which estimates the probability of selecting coal as a new industrial boiler fuel type.
Current values:	1, if boiler size is between 100 and 250 MMBtu/hr and if the plant is expected to have previous coal experience. 0, otherwise
Units:	Dimensionless number

Variable name:	**ALEXP**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FCOPT
Description:	ALEXP is a parameter in the linear regression equation which estimates the probability of selecting coal as a new industrial boiler fuel type.
Current values:	1, if boiler size is larger than 250 MMBtu/hr and if the plant is expected to have previous coal experience. 0, otherwise
Units:	Dimensionless number

Variable name:	**D45NOE**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FCOPT
Description:	D45NOE is a parameter in the linear regression equation which estimates the probability of selecting coal as a new industrial boiler fuel type.
Current values:	The product of the boiler size (MMBtu/hr) and the annual capacity utilization rate (fraction), if the boiler is located in Federal regions 4 (South Atlantic) or 5 (Midwest) and if the plant is not expected to have previous coal experience. 0, otherwise
Units:	Dimensionless number

Variable name:	**DMED**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FCOPT
Description:	DMED is a parameter in the linear regression equation which estimates the probability of selecting coal as a new industrial boiler fuel type.
Current values:	1, if boiler size is between 100 and 250 MMBtu. 0, otherwise
Units:	Dimensionless number

Variable name:	**DLARGE**
Variable type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FCOPT
Description:	DLARGE is a parameter in the linear regression equation which estimates the probability of selecting coal as a new industrial boiler fuel type.
Current values:	1, if boiler size is larger than 250 MMBtu. 0, otherwise
Units:	Dimensionless number

Variable name: **ESIM**

Variable type: Array, dimensioned 9 by 56

Program: FLCH6

Accessed by: Subroutines ESIMAD, ENDOUT

Description: ESIM(J,FIPS) is the aggregate ICE Model output projections of total industrial fossil fuel-fired boiler air emissions and costs by State (FIPS=1-56, see Appendix B).

J = 1, SO_2 emissions
J = 2, NO_x emissions
J = 3, sulfate emissions
J = 4, total annualized costs (capital, O&M and fuel for boiler and all pollution control equipment)
J = 5, total capital costs (boiler and all pollution control equipment)
J = 6, total annual non-fuel O&M costs (boiler and all pollution control equipment)
J = 7, total fuel costs
J = 8, total NO_x emissions control equipment capital costs
J = 9, total NO_x emissions control equipment O&M costs

Units: Thousand of short tons (J=1-3); millions of 1980 dollars (J=4-9)

Variable name: **BTU**

Variable type: Array, dimensioned 5 by 9 by 11 by 9 by 2

Program: TABLE6

Accessed by: Subroutines SUMTAB, OUT2

Description: BTU(FUEL or FLCAT,STATE or STINRG,REGION,TABLE or FILE,ALLNEW) is aggregate ICE Model projections of industrial boiler fossil fuel demand by fuel type (natural gas, distillate fuel oil, residual fuel oil, coal, and total), State (STINRG as above), Federal region (REGION as above), output year (FILE as above), and total new and existing (ALLNEW=1) or only new industrial boilers (ALLNEW=2).

Units: 10^{12} Btu

Variable name:	**EMI**
Variable type:	Array, dimensioned 9 by 9 by 11 by 6
Program:	TABLE6
Accessed by:	Subroutines SUMTAB, OUT1
Description:	As above, except "allowable" SO_2 emissions (I or TABLE = 2), NO_x emissions (I or TABLE = 3), sulfate emissions (I or TABLE = 4), particulate matter emissions (I or TABLE = 5), and total annualized costs (I or TABLE = 6)
Units:	Thousands of short tons (I or TABLE = 1-5); millions of 1980 dollars (I or TABLE = 6)

Variable name:	**BTU2**
Variable type:	Array, dimensioned 5 by 9 by 6 by 9
Program:	TABLE6
Accessed by:	Subroutines SUMTAB, OUT3
Description:	BTU2(FUEL,SIZCAT,CUCAT,TABLE) is aggregate ICE Model projections of fossil fuel demand in new industrial boilers by fuel type (natural gas, distillate fuel oil, residual fuel oil, coal and total), size class (SIZCAT=1-9, 8 plus total, see variable CILSO2), annual capacity utilization rate class (CUCAT=1-6; 0.25, 0.45, 0.55, 0.65, 0.75, total) and output year (TABLE=1, 1980, to 8, 2030; TABLE=9 is not used).
Units:	10^{12} Btu

Variable name:	**NUMBLR**
Variable type:	Array, dimensioned 5 by 4 by 3 by 9
Program:	TABLE6
Accessed by:	Subroutines SUMTAB, OUT4
Description:	NUMBLR(FUEL,SIZCAT2,PCLCAT,TABLE) is aggregate ICE Model projections of the total number of new industrial fossil fuel-fired boilers by fuel type (as above), size category (SIZCAT2=1-4; <100, 100-250, >250 MMBtu/hr, total), previous coal-burning experience (PCLCAT=1-3; without, with and total), and output year (TABLE as above).
Units:	Number of new industrial fossil fuel-fired boilers

SECTION 5

CONSTANTS

This section describes the major computer program constants which are used in CREATE6, FLCH6 and TABLE6 programs. They are presented by program. All major program variable and constant names are listed in the index in Appendix A.

Constant name: **IFPXST**

Constant type: Vector, dimensioned 56

Program: CREATE6

Accessed by: Subroutine INPUT

Description: IFPXST(IFIPS) is the ICE Model State code (reference Table 3-14) for each FIPS code (IFIPS=1-56, see Appendix B).

Units: Dimensionless number

Constant name: **ISTXRG**

Constant type: Vector, dimensioned 50

Program: CREATE6

Accessed by: Subroutine CREATE

Description: ISTXRG(IST) is the Federal region number (1-10, see Figure 3-1) for each State (IST=1-50, see Table 3-14).

Units: Dimensionless number

Constant name: **RETRAL**

Constant type: Scalar

Program: CREATE6

Accessed by: Subroutine DEMAND

Description: RETRAL is the annual retirement rate for annual fossil fuel consumption in industrial boilers existing in the base year.

Current value: 0.0062

Units: Dimensionless number

Constant name: **ISTXFP**

Constant type: Vector, dimensioned 50

Program: FLCH6

Description: ISTXFP(IST) is the FIPS State code (see Appendix B) for each State (IST=1-50, see Table 3-14).

Units: Dimensionless number

Constant name: **STXRG**

Constant type: Vector, dimensioned 50

Program: FLCH6

Description: STXRG(IST) is the Federal region number (1-10, reference Figure 3-1) for each State (IST=1-50, see Table 3-14).

Units: Dimensionless number

Constant name: **DISCNT**

Constant type: Vector, dimensioned 3

Program: FLCH6

Accessed by: Subroutine STREAM

Description: DISCNT(SECTOR) is the real (not nominal) after-tax discount rate by sector.

Current values: 0.12, SECTOR = 1 (existing coal-capable)
0.12, SECTOR = 2 (existing non coal-capable)
0.08, SECTOR = 3 (new)

Units: Dimensionless number

Constant name:	**PVCAP**
Constant type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines FXSTEM, GDPOL, RESID, FGDRM, PMRM, COAL
Description:	PVCAP is the after-tax present value per dollar of capital investment in new industrial boiler equipment.
Current values:	-0.7972 if ISEC = 1 or 2 -0.7626 if ISEC = 3
Units:	Dimensionless number, negative because capital costs are an expense.
Storage location:	COMMON/DUMMY/

Constant name:	**PVOM**
Constant type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines FXSTEM, GDPOL, RESID, COAL, FGDRM, PMRM
Description:	PVOM is the after-tax present value per dollar of industrial boiler annual non-fuel O&M expense.
Current values:	-3.373 if ISEC = 1 or 2 -4.830 if ISEC = 3
Units:	Dimensionless number, negative because O&M costs are an expense.
Storage location:	COMMON/DUMMY/

Constant name:	BTO
Constant type:	Vector, dimensioned 4
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, RESID, RETRES, FORSUL, FORPM, FORNOX
Description:	BTO(IRES) is the Btu or heat content of residual fuel oil
Current value:	18505 (IRES=1-4)
Units:	Btu/gallon
Storage location:	COMMON/BK11/

Constant name:	DISBTU
Constant type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL, FORPM, FORNOX
Description:	DISBTU is the Btu or heat content of distillate fuel oil
Current value:	19495.3
Units:	Btu/gallon
Storage location:	COMMON/BK23/

Constant name:	DISSO2
Constant type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FLSPEC, FORSUL
Description:	DISSO2 is the distillate fuel oil SO_2 emission rate
Current value:	20.0
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/BK23/

Constant name:	DISPM
Constant type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORPM
Description:	DISPM is the distillate fuel oil PM emission rate.
Current value:	1.5
Units:	(lb PM/MMBtu) * 100
Storage location:	COMMON/BK23/

Constant name:	GASSO2
Constant type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORSUL
Description:	GASSO2 is the natural gas SO_2 emission rate.
Current value:	0.06
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/BK22/

Constant name:	GASPM
Constant type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, FORPM
Description:	GASPM is the natural gas PM emission rate.
Current value:	1.0
Units:	(lb PM/MMBtu) * 100
Storage location:	COMMON/BK22/

Constant name:	SULO
Constant type:	Vector, dimensioned 4
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, RESID, RETRES, FORSUL
Description:	SULO(IRES) is the uncontrolled SO_2 emission rate by residual fuel oil type.
Current values:	321, IRES = 1 171, IRES = 2 79.9, IRES = 3 32, IRES = 4
Units:	(lb SO_2/MMBtu) * 100
Storage location:	COMMON/BK11/

Constant name:	PMO
Constant type:	Vector, dimensioned 4
Program:	FLCH6
Accessed by:	Subroutines FLSPEC, RESID, RETRES, FORPM
Description:	PMO(IRES) is the uncontrolled PM emission rate by residual fuel oil type.
Current values:	23, IRES = 1 13, IRES = 2 8, IRES = 3 4, IRES = 4
Units:	(lb PM/MMBtu) * 100
Storage location:	COMMON/BK11/

Constant name: SO4COL

Constant type: Array, dimensioned 11 by 10 by 2

Program: FLCH6

Accessed by: Subroutine CHOOSE

Description: SO4COL(ICOL2 or ICMTY2,IREG,J) is the coal sulfate emission rate by coal type (ICOL2 or ICMTY2=1-11; 1-7, bituminous; 8-11, subbituminous), Federal region (IREG=1-10, see Figure 3-1), and compliance alternative (J=1, no scrubber; J=2, scrubber).

Current values:

ICOL2	IREG	J	Value
1-7	1-5	1	0.0265
8-11	1-5	1	0.0129
1-11	6-10	1	0.0129
1-7	1-5	2	0.0046
8-11	1-5	2	0.0076
1-11	6-10	2	0.0076

Units: lb/short ton/percent sulfur of the coal type/100

Constant name: SO4RES

Constant type: Array, dimensioned 4 by 2

Program: FLCH6

Accessed by: Subroutine CHOOSE

Description: SO4RES(IRES,J) is the sulfate emission rate by residual fuel oil type (IRES=1-4) and compliance alternative (J=1, no scrubber; J=2, scrubber).

Current values:

IRES	J=1	J=2
1	0.1062	0.0525
2	0.0567	0.0280
3	0.0283	0.0140
4	0.0106	0.0053

Units: lb/MMBtu

Constant name: CTRLEA

Constant type: Vector, dimensioned 9

Program: FLCH6

Accessed by: Subroutine NOXCAL

Description: CTRLEA(IFLTYP) is the low excess air controlled NO_x emission rate by fuel type.

Current values:

IFLTYP	Value
1 = natural gas	not a constant*
2 = distillate fuel oil	not a constant*
3 = 3.0% S residual fuel oil	42.5
4 = 1.6% S residual fuel oil	30.5
5 = 0.8% S residual fuel oil	19.5
6 = 0.3% S residual fuel oil	14.5
7 = underfeed stoker coal	32.0
8 = spreader stoker coal	47.5
9 = pulverized coal	67.0

Units: (lb NO_x/MMBtu) * 100

*Varies with boiler size and annual capacity utilization rate

Constant name: CTRSCA

Constant type: Vector, dimensioned 9

Program: FLCH6

Accessed by: Subroutine NOXCAL

Description: CTRSCA(IFLTYP) is the staged combustion air NO_x emission rate by fuel type.

Current values:

IFLTYP	Value
3 = 3.0% S residual fuel oil	24.5
4 = 1.6% S residual fuel oil	22.0
9 = pulverized coal	58.0

Units: (lb NO_x/MMBtu) * 100

Constant name: **STXRG**

Constant type: Vector, dimensioned 50

Program: TABLE6

Description: STXRG(ST) is the Federal region number (1-10, see Figure 3-1) for each State (ST=1-50, see Table 3-14).

Units: Dimensionless number

Constant name: **FSTXRG**

Constant type: Vector, dimensioned 56

Program: TABLE6

Description: FSTXRG(J) is the Federal region number (1-10, see Figure 3-1) for each State (FIPS code, J=1-56, see Appendix B).

Units: Dimensionless number

Constant name:	STALPH
Constant type:	Vector, dimensioned 56
Program:	TABLE6
Description:	STALPH(J) is the number for each State (FIPS code, J=1-56, see Appendix B) ordered alphabetically within a Federal region.
Units:	Dimensionless number

Constant name:	STXSIR
Constant type:	Vector, dimensioned 50
Program:	TABLE6
Description:	STXSIR(ST) is the number for each State (ST=1-50, see Table 3-14) ordered alphabetically within a Federal region.
Units:	Dimensionless number

Constant name: ELECR

Constant type: Scalar

Program: FLCH6

Accessed by: Subroutines FGDCAL, FBC

Description: ELECR is the average industrial electricity price.

Current value: 0.0258

Units: 1978 $/kWhr

Constant name: SWDR

Constant type: Scalar

Program: FLCH6

Accessed by: Subroutines FGDCAL, FBC

Description: SWDR is the solid waste disposal cost.

Current value: 0.01656

Units: 1978 $/kg

Constant name: WTRR

Constant type: Scalar

Progam: FLCH6

Accessed by: Subroutines FGDCAL, FBC

Description: WTRR is the average cost of water.

Current value: 0.04

Units: 1978 $/cubic meter

Constant name: SASHR

Constant type: Scalar

Program: FLCH6

Accessed by: Subroutine FGDCAL

Description: SASHR is the sodium carbonate cost.

Current value: 0.099

Units: 1978 $/kg

Constant name: **XLWDR**

Constant type: Scalar

Program: FLCH6

Accessed by: Subroutine FGDCAL

Description: XLWDR is the liquid waste disposal cost.

Current value: 0.105

Units: 1978 $/cubic meter

Constant name: **SPRVR**

Constant type: Scalar

Program: FLCH6

Accessed by: Subroutines FGDCAL, FBC

Description: SPRVR is the supervision labor rate.

Current value: 15.63

Units: 1978 $/hr

Constant name:	**DLWR**
Constant type:	Scalar
Program:	FLCH6
Accesssed by:	Subroutines FGDCAL, FBC
Description:	DLWR is the direct labor rate.
Current value:	12.02
Units:	1978 $/hr

Constant anme:	**XMANTR**
Constant type:	Scalar
Program:	FLCH6
Accessed by:	Subroutines FGDCAL, FBC
Description:	XMANTR is the maintenance labor rate.
Current value:	14.63
Units:	1978 $/hr

Constant name:	**ALIMER**
Constant type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FGDCAL
Description:	ALIMER is the cost of lime.
Current value:	0.039
Units:	1978 $/kg

Constant name:	**ALS**
Constant type:	Scalar
Program:	FLCH6
Accessed by:	Subroutine FBC
Description:	ALS is the cost of limestone.
Current value:	0.009
Units:	1978 $/kg

APPENDIX A

INDEX OF MAJOR ARRAYS, SCALARS AND CONSTANTS

ABSDOL,63
ALEXP,65
ALIMER,87
ALLNEW,67
ALS,87
AMEXP,64
AQRDST,17
ASH,44
BASECL,26
BASEOG,26,38
BASERC,27
BCAPT,42
BLRDST,21
BOM,42
BT,46
BTO,75
BTU,67
BTU2,68
BTURTC,27
CAPCOL,41
CAPNEW,47
CILPM,50
CILSO2,49
CLCU,59
CLPRST,46
COALRT,34
COSCOL,60
COSDIF,62
COSDIS,61
COSGAS,61
COSMIN,62
COSRES,60
CPX,63
CSFLR,56
CSMIN,58
CSREC,57
CTRLEA,80
CTRSCA,80
CUCAT,68
CUMNW,26,37
CURBTU,34
D45NOE,65
DISBTU,75
DISCNT,73
DISPM,76
DISSO2,76
DLARGE,67
DLWR,86
DMED,66
DUALFR,24,30
ELECR,83
EMI,68
ESIM,67
EXLSC,58
EXLSR,54
FIPS,B-1
FLCAT,67
FLOOR,55
FOB,47
FSTXRG,81
FUEL,67
FUELPR,25
GASPM,77
GASSO2,77
IAQCR,24
IBLRCS,24
IBLRTP,24,30
IBTUS,24
ICLBLR,24,30
ICMTY2,79
ICODE,39
ICOL,40
ICU,23,24
IFCOPT,18,19
IFIPS,B-1
IFLTYP,80
IFPXST,71
IFROM,24,61
IFUEL,24,30
ILIFE,24
IPOLUT,25,32
IPRCL,24
IPRCLX,24
IRAN6D,24
IREGU,24,39
IRES,40
IRETCL,27
ISEC,24,25
ISIC,21,24,30
ISIPS,24,35,39
ISIPSZ,20
ISIZE,24
IST,24,31
ISTRT,61
ISTXFP,72
ISTXRG,71

ISZ,23
IYEAR,22
JSEC,24,25
JYR,24
NUMBLR,69
NUMCOL,28
NYEAR,22
OGPRST,48
OMCOL,41
OMNEW,48
OTHR,49
PCLCAT,69
PERIOD,22
PM,44
PMC,43
PMO,78
POLSPC,25,32
PRCLFR,35
PVCAP,74
PVOM,74
RATE,59
RECMIN,57
RECMND,56
REDSUL,45
REGION,29,64
RETCAP,23
RETRAL,72
RETROC,27
RFBC,22
RLCU,55
RSIFLR,51
RSIMIN,53
RSIMND,52
SALLOW,25
SASHR,84
SECTOR,73
SEXP,64
SFLR,52
SIPEQU,20
SIZCAT,68
SIZCAT2,69
SMIN,54
SMPM,51
SMSO2,50
SO4COL,79
SO4EMI,25
SO4RES,79
SPRVR,85
SREC,53
STALPH,82
STINRG,67
STXRG,73,81
STXSIR,82
SUL,43
SULF,45
SULO,78
SWDR,83
TABLE,67,68
TBTUS,36
TOTDEM,34
WTRR,84
XCL85,36
XCL90,36
XCL95,36
XGRATE,37
XKEPCL,34
XKEPOG,37
XLWDR,85
XMANTR,86
XNEWNW,38
XNEW85,37
XNEW90,37
XNEW95,37
XOG85,38
XOG90,38
XOG95,38

APPENDIX B

NATIONAL BUREAU OF STANDARDS
FEDERAL INFORMATION PROCESSING STANDARDS (FIPS)
STATE CODES

01	Alabama	22	Louisiana	40	Oklahoma
02	Alaska	23	Maine	41	Oregon
04	Arizona	24	Maryland	42	Pennsylvania
05	Arkansas	25	Massachusetts	44	Rhode Island
06	California	26	Michigan	45	South Carolina
08	Colorado	27	Minnesota	46	South Dakota
09	Connecticut	28	Mississippi	47	Tennessee
10	Delaware	29	Missouri	48	Texas
11	DC	30	Montana	49	Utah
12	Florida	31	Nebraska	50	Vermont
13	Georgia	32	Nevada	51	Virginia
15	Hawaii	33	New Hampshire	53	Washington
16	Idaho	34	New Jersey	54	West Virginia
17	Illinois	35	New Mexico	55	Wisconsin
18	Indiana	36	New York	56	Wyoming
19	Iowa	37	North Carolina		
20	Kansas	38	North Dakota		
21	Kentucky	39	Ohio		

APPENDIX C

FLOWCHARTS FOR SELECTED SUBROUTINES

Figures C-1 and C-2 illustrate the sequence of steps in three subroutines in the FLCH3 program (see Figure 2-4). Subroutines RESID and COAL have the same general structure and are summarized in Figure C-1. These subroutines determine the least-cost (lowest total after-tax net present value of boiler and pollution control equipment capital, O&M and fuel costs) residual fuel oil type (one of four) and coal type (one of up to 11) for each new industrial boiler -- one boiler at a time. Subroutine FCOPT, outlined in Figure C-2, implements the EEA statistical fuel choice decision module, one of two fuel choice options for new industrial boilers in the ICE Model. This subroutine is called only if the model user exercises the option ("FO=Y"), the standard operating procedure. If the model operator selects "FO=N", the fuel choice is based on the lowest cost alternative. See Tables 3-3 and 3-4. Subroutine FCOPT is called (only if "FO=Y") for each individual new industrial boiler fuel choice decision.

FIGURE C–1

Subroutines RESID And COAL

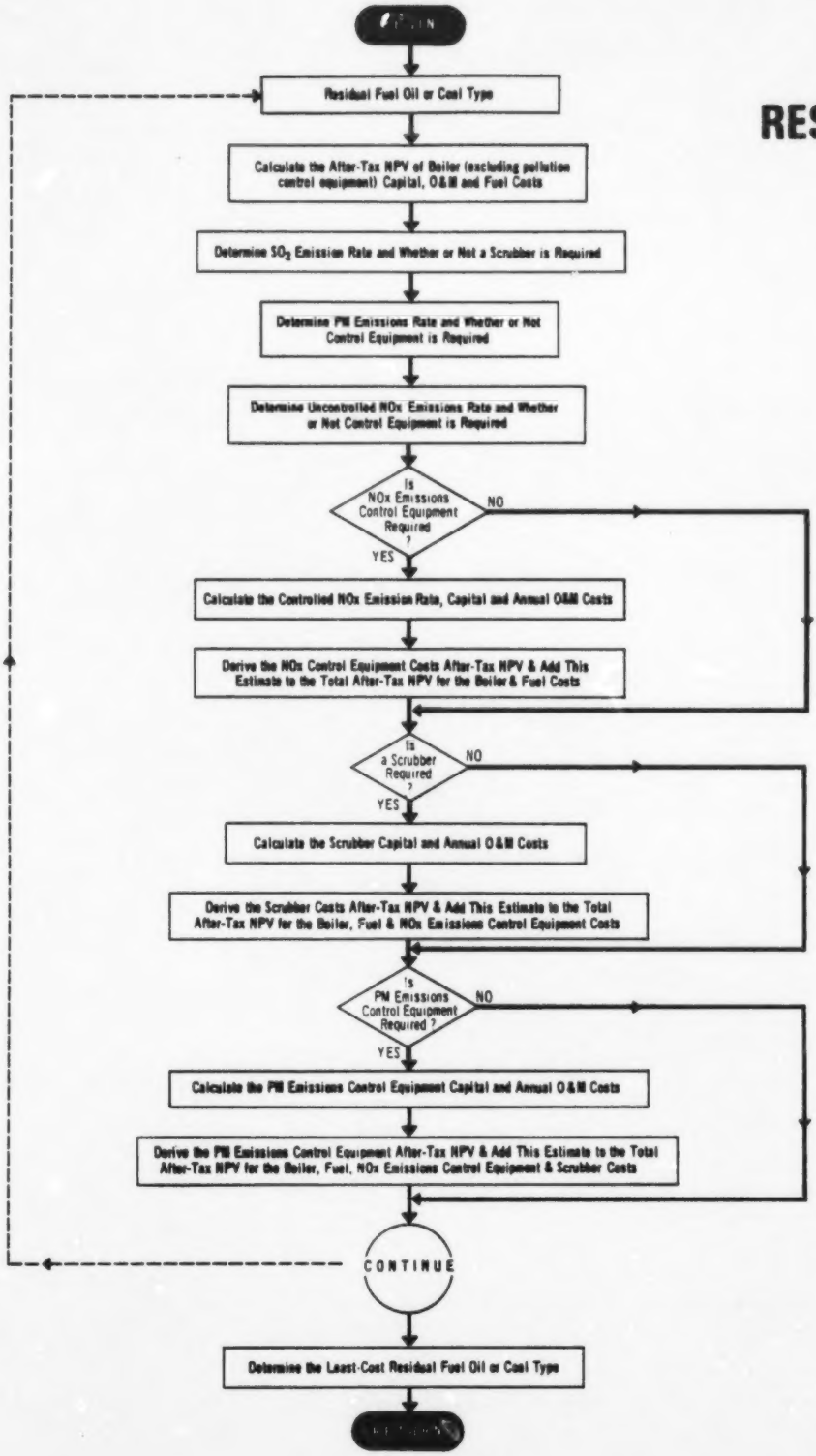
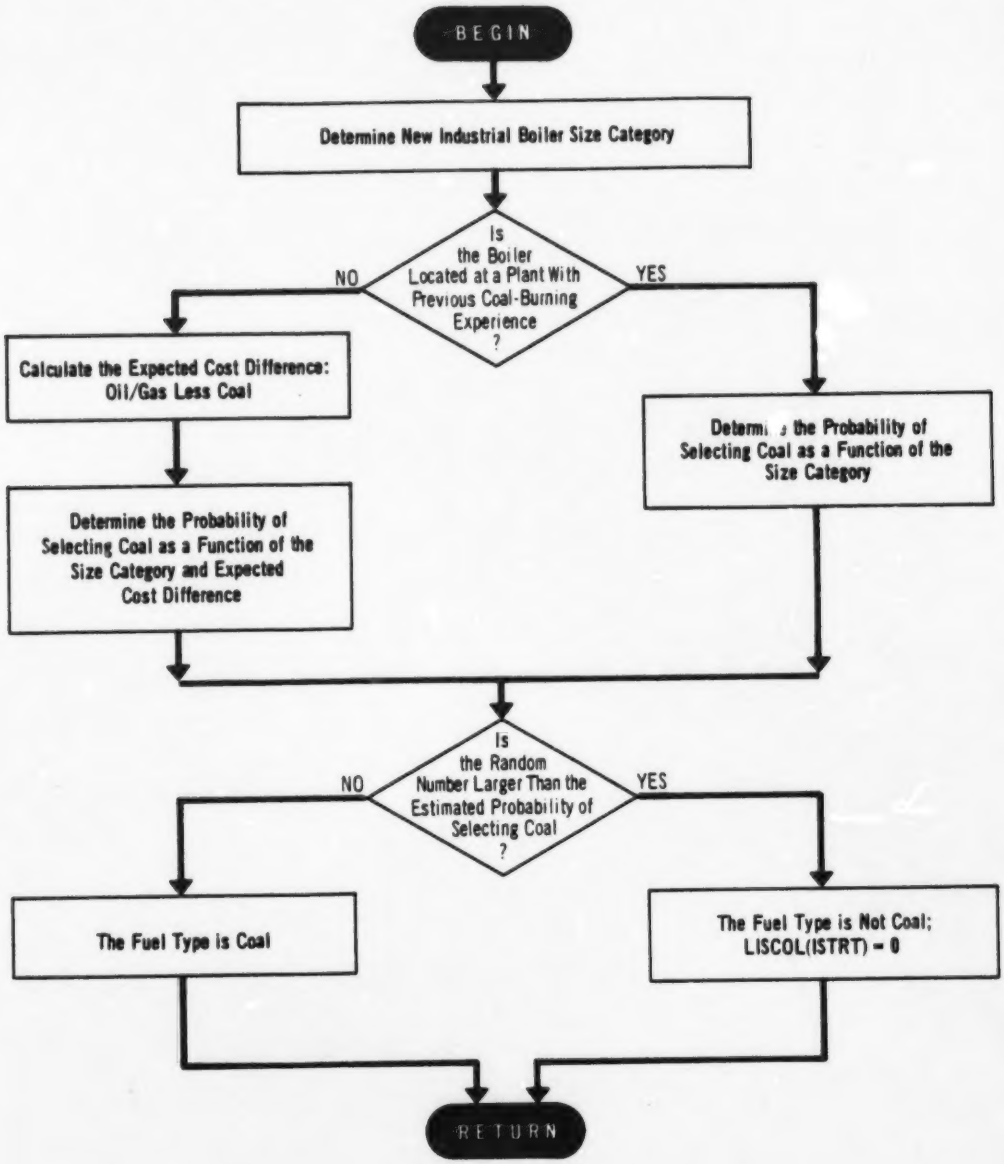

Residual Fuel Oil or Coal Type
Calculate the After-Tax NPV of Boiler (excluding pollution control equipment) Capital, O&M and Fuel Costs
Determine SO_2 Emission Rate and Whether or Not a Scrubber is Required
Determine PM Emissions Rate and Whether or Not Control Equipment is Required
Determine Uncontrolled NOx Emissions Rate and Whether or Not Control Equipment is Required
Is NOx Emissions Control Equipment Required ?
NO
YES
Calculate the Controlled NOx Emission Rate, Capital and Annual O&M Costs
Derive the NOx Control Equipment Costs After-Tax NPV & Add This Estimate to the Total After-Tax NPV for the Boiler & Fuel Costs
Is a Scrubber Required ?
NO
YES
Calculate the Scrubber Capital and Annual O&M Costs
Derive the Scrubber Costs After-Tax NPV & Add This Estimate to the Total After-Tax NPV for the Boiler, Fuel & NOx Emissions Control Equipment Costs
Is PM Emissions Control Equipment Required ?
NO
YES
Calculate the PM Emissions Control Equipment Capital and Annual O&M Costs
Derive the PM Emissions Control Equipment After-Tax NPV & Add This Estimate to the Total After-Tax NPV for the Boiler, Fuel, NOx Emissions Control Equipment & Scrubber Costs
CONTINUE
Determine the Least-Cost Residual Fuel Oil or Coal Type

FIGURE C–2

Subroutine FCOPT


BEGIN
Determine New Industrial Boiler Size Category
Is the Boiler Located at a Plant With Previous Coal-Burning Experience ?
NO
YES
Calculate the Expected Cost Difference: Oil/Gas Less Coal
Determine the Probability of Selecting Coal as a Function of the Size Category and Expected Cost Difference
Determine the Probability of Selecting Coal as a Function of the Size Category
Is the Random Number Larger Than the Estimated Probability of Selecting Coal ?
NO
YES
The Fuel Type is Coal
The Fuel Type is Not Coal; LISCOL(ISTRT) = 0
RETURN

APPENDIX D
CONVERSION FACTORS AND ABBREVIATIONS

Btu * 1.05506 = kJ	kiloJoule
Btu/lb * 2.326 = kJ/kg	kiloJoule/kilogram 2.326 = 1.05506/0.4536
lb/MMBtu * 429.922 = ng/J	nanogram/Joule
short ton * 907.185 = kg	kilogram
short ton * 0.907185 = Mg	Megagram (or metric ton)
lb * 0.4536 = kg	kilogram
MMBtu/short ton * 1.163 = J/g	Joule/gram 1.163 = 1.05506/0.907185
lb/MMBtu * MMBtu/hr * 3.6 = kg/hr	kilogram/hour 3.6 = 3.412 * 1.05506
(MMBtu/hr) / 3.412 = MW	Megawatt
acfm / 2118.9 = m^3/sec	cubic meters/second

Btu = British thermal unit
MMBtu = Million Btu
short ton = 2,000 lb